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FINAL ENGINEERING REPORT

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PRELIMINARY DESIGN
FOR A
RUGGEDIZED IMAGING SYSTEM

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TABLE OF CONTENTS

APPENDICES

LIST OF ILLUSTRATIONS

LIST OF TABLES

SECTION 1

INTRODUCTION

This report summarizes the results of a developmental effort on a ruggedized TV camera undertaken by the Ryan Aeronautical Company on 9 January 1967 and extending through 11 August 1967. The statement of work from the covering contract, JPL Number 951572, (see Appendix A) describes the task as primarily a redesign of the Mariner C television camera utilizing contemporary components and techniques to realize an immunity to the effects of sterilization and high impact shock. A complete functional ruggedized imaging system breadboard was designed, developed and tested. The design incorporates features which, when advanced to the prototype stage, will contribute significant resistance to the effect of high impact shock and sterilization procedures. Operating at three-fourths the power of the Mariner C imaging system, the measured performance was superior to that of its predecessor. It would also be considerable lighter and smaller when packaged as the Mariner C imaging system.

SECTION 2

SUMMARY

1. Design Task - The design task for the most part is described in the contract's statement of work which is given in Appendix A. The design task was to design, build, and test a breadboard of a television camera having roughly twice the performance of the Mariner C television camera, but be 30% smaller and 20% lighter, have 25% less power consumption and be able to survive sterilization and 3000 g's impact. The task was to be completed by a design specialist, a junior engineer and a technician in six months. The design task was completed in seven months. A portion of the additional month expended was the result of a change from electrostatic to magnetic deflection of the vidicon. Table 1 presents the design goals of the Ruggedized Imaging System versus Mariner C Imaging System characteristics.

2. Design Features - Features of the design which make it immune to component variations and extremes of environment include the following:

   a. A synchronous timing system coordinated through the use of a completely integrated timing chain and logic to the basic 1.54 mc clock.

   b. Operational type integrators were used for the deflection circuits to obtain high stability and precision. Tantalum capacitors were eliminated from use in timing and signal generation.

   c. A high input impedance analog-to-digital converter with a measured error of one-fifth of the smallest level of quantization over a temperature range of -50°C to +100°C.

   d. Inherently stable stages of amplification having bandpass characteristics and using integrated operational amplifiers.

e. A precision video detector having an order of magnitude better linearity than the Mariner C Detector.

f. A simpler, more reliable, shutter drive circuit than that used in the Mariner C system.

Due to limitation of time and funds, certain compromises were made in noncritical areas. These compromises included the following items:

a. Simple power supply design.

b. The use of restricted range rather than full MIL type integrated circuits.

c. The use of components which would not be used in the prototype.

d. The limitation of temperature testing to critical circuits.

Special emphasis was placed on areas of design which were judged to be critical to performance or were considered to be potentially sensitive to the effects of sterilization or shock.

3. Brief System Description - A functional block diagram of the ruggedized TV system is shown in Figure 2. The input to the system is a visual image which is allowed to strike the photoconductor on the face plate of the vidicon when the shutter is opened. Readout of the photoconductor is provided by an electron beam which is scanned by the vertical and horizontal deflection circuits. The deflection circuits drive coils in the magnetic yoke. The electron beam is modulated by the beam modulator at a 76 KHz rate to increase sensitivity and provide a carrier for the video signal. The amplitude modulated video signal from the vidicon proceeds through the RF amplifier and filter, where it is filtered, amplified and applied to attenuators which are controlled by the gain control

computer so that the signal entering the detector is maintained near an optimum level. Gain control is also required to prevent saturation of following stages. The detector recovers the video information and a keyed clamp restores the d.c. level before sending the signal to the encloder. The encoder periodically samples the d.c. restored video signal and converts it to a 6 bit binary number equivalent to the video level. The resultant pulse code modulated signal is then sent to output buffers where it and associated sync signals are buffered for interface with other equipment. The PCM signal is also sent to the gain control computer where the level information is used to determine the required attenuator settings for optimum input to the detector. The clock and timing block contains a 1.54 MHz clock, a divider chain, and logic where all timing and control signals are generated. Power supplies (not shown) supply all dc voltages to the system.

4. Performance - The performance of the ruggedized imaging system breadboard exceeded the Mariner C design specification by approximately a factor of two in many areas. Significant performance parameters are summarized below:

a. Relative response is 17% for a 400 line pattern.

b. Signal-to-noise ratio is 43.6 db for 0.1 foot-candle-seconds illumination.

c. Encoding resolution is ±1 bit or 1 part out of 63 (1.6%).

d. Encoding error is less than ±0.2 bit or ±0.32% over a temperature range -50°C to 100°C.

e. Scan nonlinearity is less than 0.5%.

Photographs of images taken by the camera as displayed on a monitor are given in Figure 3.

5. <u>Hardware Status</u> - At the conclusion of the task a complete functional ruggedized imaging system breadboard was left at JPL. A picture of the system, taken during the evaluation tests, is shown in Figure 1.

SECTION 3

CONSIDERATIONS GIVEN TO MEET SPECIAL ENVIRONMENTAL CONDITIONS

The special environmental test conditions to which the ruggedized TV camera will be subjected and must withstand are:

a. Shock - +3000 g modified square wave, 0.1 ms rise time, 3 ms duration, 0.1 ms fall time.

b. Sterilization

1) 12% ETO/88% Freon 12 gas exposure at 50°C and 35-55 R.H. -6 cycles, 30 hours each.

2) 6 cycles, 96 hours each, at 135°C in a dry nitrogen atmosphere.

1. General - It is desirable to use the breadboard design as a basis for a prototype development which will be subject to the exceptionally rigorous environmental conditions of sterilization and hi-impact shock. It was therefore, important to embody in the breadboard phase of development, an appropriate part of the total plan to realize "sterilizability" and "impactibility". Sterilizability and impactibility of the ruggedized imaging system will be achieved through concentration of effort in four primary areas:

a. System and Circuit Design

b. Parts and Materials Selection

c. Packaging

d. Testing and Evaluation

In the recently concluded effort, primary emphasis was placed in the area of system and circuit design. Component parts were preferentially selected from the JPL Electronic Part Sterilization Candidates list and JPL and Ryan preferred parts lists. The use of unlisted parts was based upon recommendations from component specialists, information gathered from available reports on the effects of sterilization and hi-impact shock on components, and years of experience in the design of military and space electronic equipment. Microelectronic circuits were surveyed for applicability to the program and those which seemed suitable were selected for evaluation and use.

2. <u>Design Guides</u> - To assist in achievement of the desired goals, the following set of design guides was established:

   a. Design for the required system performance.

   b. Design for minimum size and weight.

   c. Design for minimum power consumption consistent with the preceding two points.

   d. Select components, in accordance with the following guides:

      1) Minimize the use of electro-mechanical components; e.g. pots, relays, stepping switches, etc.

      2) Avoid large mass components like most transformers and large capacitors. Attempt to keep all component heights below 0.4 inch.

      3) Where possible, avoid the use of even small transformers.

      4) Where possible, select components from the JPL Electronic Part Sterilization Candidates list, JPL Preferred Parts List, Ryan

Space Projects Preferred Parts list, or MIL specs, in order of preference. In the event that the selected component is not available, use in-house components for the breadboard, but call out the preferred part on the schematic.

3. Design Features - The requirement to improve performance and the requirement to design in resistance to the effects of shock and sterilization were generally compatible. In every case but one where there is increased complexity or parts count over the Mariner C, there is justification, not only in performance improvement, but in the elimination of parts that were exceptionally sensitive to shock and/or sterilization. The one exception was the precision detector, where improved performance was the only benefit. The use of the relatively non-linear Mariner C detector, though much simpler, would have caused as much as 7 DN (bits) error (greater than 50%) at the low input levels. The measured error of the precision detector throughout its dynamic range was ±0.25 DN or ±1%, whichever is greater.

   The following design features contribute to system resistance to shock and/or sterilization.

   a. Timing - All timing is synchronized to a 1.54 mc master clock. Although the flip flops and gates have delays, they are small and specified.

   b. Amplifiers - The three signal amplifiers employ integrated circuit operational amplifiers and feedback. With gain determined primarily by the feedback and input resistors (which can be precision, low temperature coefficient types) high gain stability can be achieved, thus giving considerable resistance to environmentally induced parametric changes. The 40 gain and 100 gain amplifiers incorporate frequency variant feedback to give desirable bandwidth characteristics. Combining the filtering and amplification in the active filter provides a five to ten times reduction in the required inductor size, and being low Q filters, small changes in L or C will not seriously affect performance.

c. Deflection Circuits - Feedback integrators were developed in which the critical capacitor could be much smaller than in the Mariner C system. This made it practical to use much more stable and accurate polycarbonate or teflon capacitors, rather than tantalum.

d. General - Except for pots, which will be removed in the prototype, and the shutter, there are no electromechanical parts in the system. There are no tantalum or ceramic capacitors used in timing or signal generation. There are no transformers, except the required power supply transformers, and only two small inductors.

4. Parts - Electronic parts were selected from the JPL Electronic Part Sterilization Candidates List, JPL Preferred Parts List, Ryan Space Projects Preferred Parts List, or MIL Specs, in order of preference. Other components which are expected to be sensitive to the special environment are the vidicon, optics, and the shutter. Work performed by RCA has led to the development of a vidicon that will meet the sterilization and shock requirement. As far as is known, there are no available hyper-ruggedized shutter or optics. Their development, or alternatives to their use, are under consideration at JPL. Some non-preferred parts used in the breadboard include polycarbonate capacitors, potentiometers, and two large tantalum storage capacitors in the shutter drive circuit. Potentiometers are used in the breadboard for ease of adjustment, and would be replaced by fixed resistors in a prototype model. Large tantalum storage capacitors were used to supply surge current demands for the shutter circuit of the Mariner C shutter. Because of uncertainty in the final shutter mechanism for the ruggedized imaging system, large capacitors were again used to drive the Mariner C type shutter. An effort should be made to eliminate the need for high surge currents required for this shutter and hence the need for large capacitors. The use of polycarbonate capacitors in the deflection circuits are of some concern due to reported failures during sterilization. There is reason to believe, however, that burning in, pre-cycling, and screening, will result in the availability of suitable polycarbonate capacitors. The

use of these capacitors should be verified at the earliest opportunity. Although teflon capacitors could be used, they are several times larger than the polycarbonate type.

In the ruggedized imaging system breadboard, two types of hybrid circuits are used, voltage regulators made by General Instrument, and analog FET switch drivers made by Siliconix. Although the schedule did not permit rigorous evaluation of these hybrids under different environments, no malfunctions or out of specification performance was noted.

Transistors, integrated circuits and hybrids are commonly specified and tested to above 10,000 g of acceleration. Both transistors and integrated circuits in general can meet the heat sterilization requirement. Failures during heat sterilization of integrated circuits have been primarily attributed to poor quality control. Therefore, it is believed that failure during sterilization could be greatly reduced by acceleration testing, temperature cycling, burn-in, and screening. Considering the relatively few numbers of ruggedized imaging systems which will be built, the additional cost of such testing to weed out marginal devices is worthwhile.

The use of hybrids offers great potential reductions in size and weight. In addition, reliability is enhanced because internal components and their interconnections operate within a hermetically sealed environment. Reduction of size to a reasonable limit could be accomplished by implementing as many functions as possible with commercially available integrated circuits and hybrids, and custom hybridizing the remaining circuitry. Short term thermally induced parameter variations in hybrids are minimized by placing components on the same substrate. This can be used to great advantage in resistor networks where ratios rather than absolute values are of prime importance.

The parts referenced in the parts list, with the exceptions noted, are believed to be the best parts available for the ruggedized imaging system.

SECTION 4

TECHNICAL DESCRIPTION

This section contains both a description of the system and a brief description of the circuitry. To separate the two for those primarily interested in the system circuit description has been inset. The Detail Block Diagram of the ruggedized imaging system is shown in Figure 5. The Schematic Diagram is given in Figure 7. All system timing and logic signals are generated in the CLOCK AND DIVIDER CHAIN and TIMING GENERATOR and CONTROL LOGIC blocks. The 1.54 MHz clock and a succession of flip flop countdown stages are represented by the CLOCK AND DIVIDER CHAIN. Some of the signals from the divider chain are used directly but most of the system timing and control signals are developed by the TIMING GENERATOR and LOGIC circuits logically selecting and combining signals from the divider chain. Key system timing and control signals are identified in the block diagram. Timing charts are contained in Figures 6A through 6E. The identity numbers 2 through 28 on Figure 6A and 6B identify the signals which will be seen at pins 9 of flip-flops 9040-2 through 9040-28.

> All timing and control circuitry is on circuit boards 1 and 2. All IC's are identified by two numbers, an IC number and the type number with a dash and another number which refers only to that type; e.g. there will be a (DTLPμL) 9040-1, 9042-2, (DTμL) 951-1, 933-1, etc. This nomenclature was assigned during the developmental stages and carried over because it is more useful than the IC reference designators when referring to the schematic.
>
> The clock is comprised of 2 cross coupled monostable multivibrators, DTμL 951-1 and -2. This clock configuration was chosen because it is adequately stable, uses the same supply as the rest of the logic and is simple. In a mission a primary timing signal or signals would probably be supplied from an external source. The divider chain, comprised of flip flops DTLPμL 9040-2 through

-28 is contained on both TIMING and CONTROL boards and was split to minimize the number of Board 1 and Board 2 interconnections. These two boards will be returned to later.

Besides providing required signals for signal processing the TIMING GENERATOR and CONTROL LOGIC blocks provide digital timing and control signals for what may be described as service functions. These functions will be described as service functions. These functions will be described while going through a complete camera cycle.

Approximately 80 msec before a readout period begins the SHUTTER DRIVERS receive an open shutter command and the shutter solenoid is energized. This causes the normally closed shutter to rotate 45^{o} to an open position. After 106.3 msec or 212.6 msec, determined by the GAIN CONTROL COMPUTER, a close shutter command is received by the SHUTTER DRIVERS and the shutter rotates another 45^{o} to a closed position. If the shutter is accidentally left in, or somehow jarred to an initially open position this is sensed by raised positions on a cam attached to the shutter shaft actuating a microswitch, which, in conjunction with logic in the TIMING GENERATOR and CONTROL LOGIC block, generates a signal which inhibits the close shutter pulse. Since the shutter accidentally started in the open shutter position, the open shutter command closed it and since the close shutter command was inhibited, it is in the correct closed position ready for the next picture taking cycle.

The shutter drive circuitry is on Board 1A. Q4, Q6 and Q2 are used in the open shutter circuitry while Q3, Q5 and Q1 are used in the close shutter circuitry. C1 and C2 store the energy for the two solenoid actuations and are charged between shutter periods through R2 and R1 respectively.

Following the shutter period the G1 SWITCH receives a signal which causes G1 to switch to normal readout potential. The G1 SWITCH also contains a voltage regulator that holds the potential and maintains the ripple at a low level. During the erase period the switch causes the G1 SWITCH output to be at a less negative potential to increase beam and target current, which was intended to contribute to erasing residual signal. Measurements indicate that this erase system is ineffective on the vidicons tested.

The G1 SWITCH is on Board 1. Q102, Q103 and Q104 comprise the regulator while Q105 and Q106 provide the switch function. R107 adjusts the readout voltage and R115 sets the erase voltage.

Scanning of the photoconductor during readout is provided by the SWEEP CIRCUITS. During the retrace and erase periods the horizontal sweep signal is expanded 10% so that the erased area will overlap the readout area. This function in the vertical sweep is provided by the dither signal which superimposes a 4.8 KHz triangular wave on the vertical retrace signal. The dither signal was expected to enhance the erase process but proved ineffective alone or in conjunction with the G1 switch. If the results of the JPL investigation of effective erase techniques indicate that the dither signal will serve no useful purpose, it should be removed and vertical overscan capability added to the vertical sweep circuit.

The sweep circuits are on Board 4. The 25 msec horizontal scan signal is provided by using a μA709 integrated operational amplifier, IC401, in an integrator circuit with current sensing providing the feedback signal. C405 is the integrator capacitor. At the conclusion of the 25 msec horizontal sweep Q402 is actuated, which discharges the capacitor and returns the output to a level determined by the setting of R409. Q400 and Q401 provide changes in the operational amplifier input levels during vertical retrace which effect horizontal overscan. The D111F analog FET driver IC400 is a logic level converter. The 13.6 sec vertical readout and retrace sweeps require much larger time constants than could be obtained in the horizontal sweep circuit. The vertical sweep uses the 10 meg resistor R454, a 2 μf capacitor C411 and an amplifier composed of Q410, Q409, A412, A413, A414 and Q415 in virtually the same fashion as the horizontal sweep circuit. The effect of an FET switch's finite leakage resistance on the integrator voltage is eliminated by driving the integrator back to the start point prior to the start of each readout cycle. The start point is set by R422. Q406 and Q405 comprise a comparator which senses the output voltage during retrace. If larger than the readout start point the comparator output, which is connected to the integrator input through Q407, drives the integrator output down to the start point. R433 is used to set the input drive potential during readout. Q403 and Q404 in the horizontal sweep circuit and Q414 and Q415 in the vertical sweep circuit are class AB push-pull output stages. The single layer printed circuit yoke has a resistance per coil of approximately 14 ohms. A multilayer yoke with more turns per coil and higher resistance would save power and be easier to drive.

The CATHODE CHOPPER switches the cathode between two potentials about 6 volts apart at a 76 KHz rate. The resultant beam modulation provides a 76 KHz carrier for the video signal and increases the output. During horizontal retrace it is turned off to reduce target output.

The CATHODE CHOPPER, whose input is the I signal, is comprised of Q100 and Q101 of Board 1 and located on the camera head.

During readout the target output signal which is of the order of 20 nanoamps peak to peak, is fed to a transresistance amplifier with a gain of 10^7 volts per amp. The output of the transresistance amp is fed through an adjustable voltage divider to a post amplifier which has a low Q bandpass characteristic and a gain of 100.

The input stage in the preamplifier is a low noise FET Q107. Gain is provided by a μA709 operational amplifier Q100. The 10 megohm feedback resistor, R120, sets the transresistance gain. All supply voltages are decoupled and filtered with special emphasis placed on the target bias voltage. Potentiometer R128 and resistor R129, connected to the preamp output, provide gain adjustability for the post amplifier. The post amplifier utilizes an RCA CA3010 operational amplifier IC101. Frequency selective feedback is provided by L100 and C116.

The output of the post amplifier interfaces with the ATTENUATORS and VIDEO BLANKING circuitry. The attenuators are under the control of the GAIN CONTROL COMPUTER. The amplitude modulated video signal is step attenuated to a level which will not cause saturation or limiting. A shunt switch provides blanking during horizontal retrace.

> The ATTENUATORS and VIDEO BLANKING circuitry are on Board 5. It is comprised of resistor dividers R500 and R502, R501 and R503, and R509 and R510 which have their shunt legs connected to ground by transistor switches Q500, Q501 and Q503 respectively as directed by the gain control computer. Q502 and Q504 provide isolation and buffering.

The ATTENUATORS and VIDEO BLANKING output is applied to an amplifier having a gain of 40 and low Q bandpass characteristics. The VIDEO BLANKING circuit is a part of this amplifier. Video blanking is accomplished by switching the midpoint of the input resistor to ground during horizontal retrace. The function of this amplifier is to increase the amplitude modulated signal prior to video detection.

> The 40 gain amplifier on Board 5 is comprised of a CA3010 operational amplifier, IC500, and associated components. L500 and C503 in the feedback path provide bandpass characteristics for the amplifier. The junction of the input resistors R513 and R514 is connected to ground through transistor switch R505 during horizontal retrace to provide video blanking.

The 40 gain amplifier output is connected to the DETECTOR AND FILTER input where the video information is extracted from the amplitude modulated 76 KHz signal. The detector has a maximum non-linearity of 8 mv or 1%, whichever is larger, over its 2 volt output range. The filter has an upper corner frequency at 10 KHz and rolls off at 18 db/octave.

> The DETECTOR AND FILTER are on Board 5. Placing the detection diodes CR501 and CR502 in the feedback path of the CA3010 operational amplifier, IC501, effectively reduces the non-linearities

caused by diodes. In addition the gain of the detector can be adjusted with the input and feedback resistor. Due to slew rate limitations of the μA709 and output limitations of the CA3010, it was necessary to add a gain of 2 stages after the feedback detector, and since the slew rate limitation of the μA709 was more restrictive than the output limitations of the CA3010, the cheaper CA3010 was used. Q507 is used as a gain of two amplifiers with a fairly high input resistance. Collector load resistor R533 forms part of the low output impedance active filter Q508.

The output of the filter interfaces with the BLACK LEVEL REFERENCE circuitry, where, at the beginning of each line, the video level resulting from scanning in the black mask is referenced to a predetermined level. The worst case deviation from the reference during the 25 msec line time is less than 8 mv or 1/4 DN over a temperature range of -50 to +100°C.

The BLACK LEVEL REFERENCE circuit on Board 5 is a type of keyed clamp. At the beginning of each line, G, the black level reference signal actuates series switch IC502 connecting the output of the DETECTOR and FILTER through a capacitor C514 to a predetermined voltage set by adjusting R538. The capacitor quickly changes to the difference between the FILTER output and the reference voltage. When the switch opens, the voltage at the comparator input is the reference voltage. The change in that voltage during the rest of the line time is caused by capacitor C514 discharge. It will change less than 8 mv in 25 msec.

The DETECTOR AND FILTER output is connected to the COMPARATOR input through the BLACK LEVEL REFERENCE capacitor. The COMPARATOR compares the analog video signal to an accurate ramp generated by the RAMP GENERATOR once every 52 μsec. As long as the analog video is larger than the ramp, the COMPARATOR output is a logical 1. When the ramp is equal to or larger than the analog video, the output of the COMPARATOR is a logical 0. The output of the

COMPARATOR is, therefore, a pulse width modulated signal whose pulse width is proportional to the analog video amplitude.

The COMPARATOR and RAMP GENERATOR are on Board 5. Q509, Q510 and IC504 comprise the high input impedance comparator. CR502 and CR503 provide protection for the input of the μA710. The RAMP GENERATOR is comprised of Q511 and C520. One half of Q511 is used as a constant current source, while the emitter base junction of the other half is used in providing a reference voltage, along with CR504 and CR509. IC503 is a switch which discharges C520 once every 52 μsec. The discharge is controlled by the A signal through IC505, a D111F analog FET gate driver.

The pulse width modulated signal from the COMPARATOR goes to a GATE where it is combined with the 1.54 MHz clock signal, the A encoding period signal and the output of the 63 COUNT DETECT circuit, producing a pulse modulated signal where the number of pulses is proportional to the analog video signal. The pulse modulated signal enters a 6 BIT COUNTER where the number of pulses is converted to a binary number. The contents of the 6 BIT COUNTER are sensed by the 63 COUNT DETECT circuit, which prevents the count from going beyond 63 during the encoding period and then parallel shifted into the PARALLEL IN SERIES OUT SHIFT REGISTER. While the COUNTER is counting the contents of the next pulse modulated signal, the pulse code modulated signal in the PARALLEL IN SERIES OUT REGISTER is series shifted out through the DIGITAL DATA BUFFERS to interface equipment.

The pulse width modulated signal, the 63 count limit signal, the 1.54 MHz clock signal and the A encoding period signal are ANDed in one half and inverted in the other half of 9042-8 on Board 2. The pulse modulated signal goes to a 6 bit counter which is comprised of flip flops 9040-29 through 9040-34 on Board 3. Upon receipt of the J transfer pulse, the counter output is parallel shifted through gates 9041-12 through 9041-17 to a parallel in-series out shift register comprised of flip flops 9040-35 through 9040-40. The pulse code modulated signal is shifted out of the shift register to the DIGITAL DATA BUFFER which is comprised of one gate of the 9041-24 and Q300, and from there to interface equipment. Coincident with this, gates 9042-9 and 9041-23 on Board 2 output buffer word and bit sync signals to interface equipment. One half of 9042-6 and one half of 933-4 comprise the 63 COUNT DETECT circuit.

The GAIN CONTROL COMPUTER gets its primary input from the 6 BIT COUNTER. During a part of the frame established by H, the hi level test time, the number of times the 6 BIT COUNTER equals or exceeds 62 is counted. If it does so 15 or more times, the GAIN CONTROL COMPUTER actuates a switch in the leg of the ATTENUATORS on Board 5 to throw in more attenuation, or sends a signal to the shutter drive logic which results in a shorter exposure in the next shutter period. Also, a signal is sent to the gate sensing the output of the 6 BIT COUNTER which prevents any more input to the 4 bit counter for the rest of that frame. During the vertical retrace and erase periods, the 4 bit hi level detect counter is reset, readying it for the next readout period. The 4 bit switch actuating counter may be reset by depressing the GAIN CONTROL COMPUTER button.

The design of the GAIN CONTROL COMPUTER is very similar to that of Mariner C except 3 stages of attenuation were used to provide a finer signal level correction. The following table shows the successive steps of signal reduction which result as the 4 bit counter goes from 0 to 15. It will be observed that there are several backward steps which result because the 2:1 shutter change does not fit into the attenuator pattern of $\alpha = 1.53$, $\alpha^2 = 2.25$, $\alpha^4 = 5.54$. This discrepancy was not noted until the evaluation schedule prevented modification of the logic. The system is not seriously affected as the gain control computer treats the 3 backward steps as "still not enough attenuation" conditions and proceeds to the next step. The steps of attenuation are no larger than was desired, however, the full capability of the circuitry is not exercised. In the next phase of development this discrepancy should be corrected. Since there is no shutter currently available that will take the 3000 g shock, the role of the shutter

CONDITION	Flip Flop 9040-41 $\alpha = 1.53$	Flip Flop 9040-42 Fast Shutter	Flip Flop 9040-43 $\alpha^2 = 2.35$	Flip Flop 9040-44 $\alpha^4 = 5.54$	Resultant Attenuation Factor
0					0
1	X				1.53
2		X			2 → 1.8
3	X	X			3.06 → 2.75
4			X		2.3
5	X		X		3.61
6		X	X		4.7 → 4.24
7	X	X	X		7.22 → 6.5
8				X	5.54
9	X			X	8.51
10		X		X	11.08 → 9.98
11	X	X		X	17.02 → 15.3
12			X	X	13.06
13	X		X	X	20.03
14		X	X	X	26.06 → 23.5
15	X	X	X	X	40.0 → 36.0

NOTE: The arrows point to Attenuation factor reduction due to photoconductor non-linearity.

ATTENUATION STATES OF GAIN CONTROL COMPUTER has yet to be defined for future systems. If a satisfactory shutter is developed, or the high shock requirements eliminated, shutter time control may give better performance than attenuator control.

During the third quarter of every line which is in the second and third quarters of the frame, the high level check signal H is true, permitting gate 9042-6 and its input expander 933-4 to sense the output of the 6 BIT COUNTER on Board 3. Each time the count reaches 62, the output of the 9042-6 gate goes down and adds one count to the 4 bit counter, 9040-41 through 9040-44. This 4 bit counter gets reset once each frame by the $\overline{27}$ signal and when the count reaches 15, the 9042-7 gate which senses the output goes down and adds one count to the second 4 bit counter 9040-45 through 9040-48 whose outputs directly drive the ATTENUATOR switches on Board 5 and the shutter control logic. The $\overline{27}$ signal acting through 9042-7 resets the hi level detect 4 bit counter once every frame. The switch actuating 4 bit counter may be reset by depressing the GAIN CONTROL COMPUTER RESET button.

Shutter times are developed by combining signals from the divider chain. Signals from the second flip flop in the switch actuating 4 bit counter combine with signals from the divider chain and the micro switch at the shutter to develope the $\overline{T_0}$ open shutter signal and determine whether the $\overline{T_1}$ close shutter fast or $\overline{T_2}$ close shutter slow signal should be sent to the SHUTTER DRIVE circuits. VERTICAL TRIGGER and HORIZONTAL TRIGGER signals for synchronizing the monitor with the imaging system are developed on the same board. The simple development of various other timing and control signals is displayed on the schematics of Board 2 and Board 3.

The shutter drive signals and control logic on Board 3 are comprised of gates 9042-3 and 9042-4 and gate expanders 933-1 and 933-2. Gate 9041-22 and associated capacitors, diodes, and resistors comprise the VERTICAL TRIGGER and HORIZONTAL TRIGGER generators and buffers.

The LOW VOLTAGE POWER SUPPLY on Board 5 provides +12 vdc, +6 vdc, +5 vdc, -6 vdc and -12 vdc for general circuit use, and a +50 vdc voltage for the shutter drivers. The power supply cannot be designed for optimum efficiency without good knowledge of the loads and primary power characteristics. Therefore, a simple approach, adequate to the needs of this phase of the development was used. The loads are expected to change when the final vidicon and final deflection coils are used. Because the 2500 Hz, square wave, 50 vrms lab supply was stable and had an output regulation better than 1%, the prime consideration for the ruggedized imaging system power supply was output impedance and ripple. Hybrid regulators in 1/4 x 1/8 flat packs were used for the +12 vdc, +6 vdc, -6 vdc and -12 vdc supplies, and gave better than 1% regulation over all output current ranges. For the other output voltages, the series filter resistors were maintained low enough to obtain reasonable dc output impedances and the filter capacitors were made large enough to keep the ripple down. The High Voltage Supply on Board 6 contains only one emitter follower type regulator.

SECTION 5

MEASURED PERFORMANCE OF THE CAMERA SYSTEM

A summary of system performance is given below.

1. Typical Monitor Presentations - Three pictures of monitor displays are presented in Figure 3. After several stages of reproduction they are somewhat degraded, but give a general view of typical displays. The black area to the left is the black mask, with the three white spots being blemishes in the vidicon. The shading in the upper and lower right corners is due to the hole in the shutter mounting being too small. The cause of the dark bar across the bottom was undetermined. It bears some similarity to the phenomena noted in the Mariner C camera, wherein the solenoid field was believed to be the cause. Note, however, that the line is quite straight and occurs at the bottom of the frame, some 14 seconds after the shutter pulses. It could be peculiar to the vidicon. Due to the unavailability of a ceramic vidicon, a Mariner 64 vidicon whose intended scan area is one fourth the ceramic vidicon area was used.

2. Transfer Curve - The transfer curve of detector output versus light intensity is shown plotted in Figure 4. Note that it is a plot of detector output versus filter light transmission factor. The measurements were made by interposing filters having different transmission factors between the 0.095 foot-candle-second light source and the lens. With a preamp input to detector output gain of 130 mvdc/na peak target current, the peak target current at 0.095 foot-candle-seconds illuminization was 23.1 na.

3. Residual Image - Residual image was measured by taking two successive pictures of a vertical bar pattern, noting the high light video output, and comparing it with that of a successive readout only cycle. It was

observed that the readout only video output was a little less than 50% of the preceding video output. It was also noted that no combination of the G1 switch (which makes G1 less negative during vertical retrace) and vertical dither (which superimposes a 4.8 Kc triangular deflection on the 13 second vertical retrace) caused any appreciable residual image reduction. While the tube may have been a "sticky" one, the tests demonstrated the ineffectiveness of the erase techniques which seemed reasonable but did not work. An investigation of effective erase techniques was underway in another JPL group at the conclusion of this effort and the results should be incorporated in the ruggedized imaging system.

4. Resolution - The resolution was measured using 35mm resolution pattern slides. The relative response was 58% for the 200 line pattern and 17% for the 400 line pattern.

5. Signal-to-Noise Ratio - The rms noise at the detector was 20 mv. At 0.1 foot-candle-seconds illumination, the peak signal to rms noise ratio at the detector output was 43.6 db. At 0.01 foot-candle-seconds it was 27 db.

6. Encoding Accuracy - The encoder has a basic resolution of ±1 bit, or (1/63) 100 = 1.6%. The additional error contributed by drift and non-linearity was less than ±0.2 bit over a temperature range of -50°C to +100°C.

7. Scan Linearity - Because of the unknown contributions of the yoke and its mechanical orientation and the closeup effects in the optics resultant from the inability to position the vidicon as close to the lens as was desirable, the total non-linearity of the system was not measured. It appeared to be several percent. The deflection circuits, however, are capable of producing drive currents linear to better than 1%. Using a Sanborn chart recorder the vertical drive non-linearity was measured

as ±0.25%, however, the Sanborn itself can have that much potential non-linearity. The horizontal non-linearity as measured on an oscilloscope was less than 0.5%.

8. Shutter Speeds - The two shutter speeds as measured by a solar cell and oscilloscope were 105.4 m sec and 210 m sec.

9. Gain Control Computer Accuracy - The gain control computer accuracy is primarily a function of resistor values in the attenuators. Tests were performed to verify that the gain control computer was working properly and that the attenuator stages were approximately correct.

10. Power - Because several secondary voltages were too low in the developmental power supply transformers, the 2400 Hz input voltage was set 12% high. Under this condition, the average input power was 6.44 watts. Correcting for the overvoltage, the average input power would be approximately 5.4 watts. This is a substantial reduction below the 8 watts of the Mariner C imaging system.

11. Size and Weight - Being in the breadboard stage, it is impossible to compare the size and weight of the ruggedized imaging system with those of the Mariner C imaging sytem, however, a comparison of the component parts count of the two systems will be informative. The Mariner C imaging system contained 1230 components and 60 modules. Estimating the average module contents at 10 parts per module brings the total to 1830 component parts. The ruggedized imaging system has 563 component parts, of which 101 are monolithic integrated circuits or hybrids. The ratio of the component parts count between the two systems is 3.25. Because of the dominating influence of large components common to both systems, however, and the equalizing mass of the support structures, the difference between the Mariner C imaging system and a similarly packaged prototype ruggedized imaging system would be much less.

SECTION 6

ILLUSTRATIONS

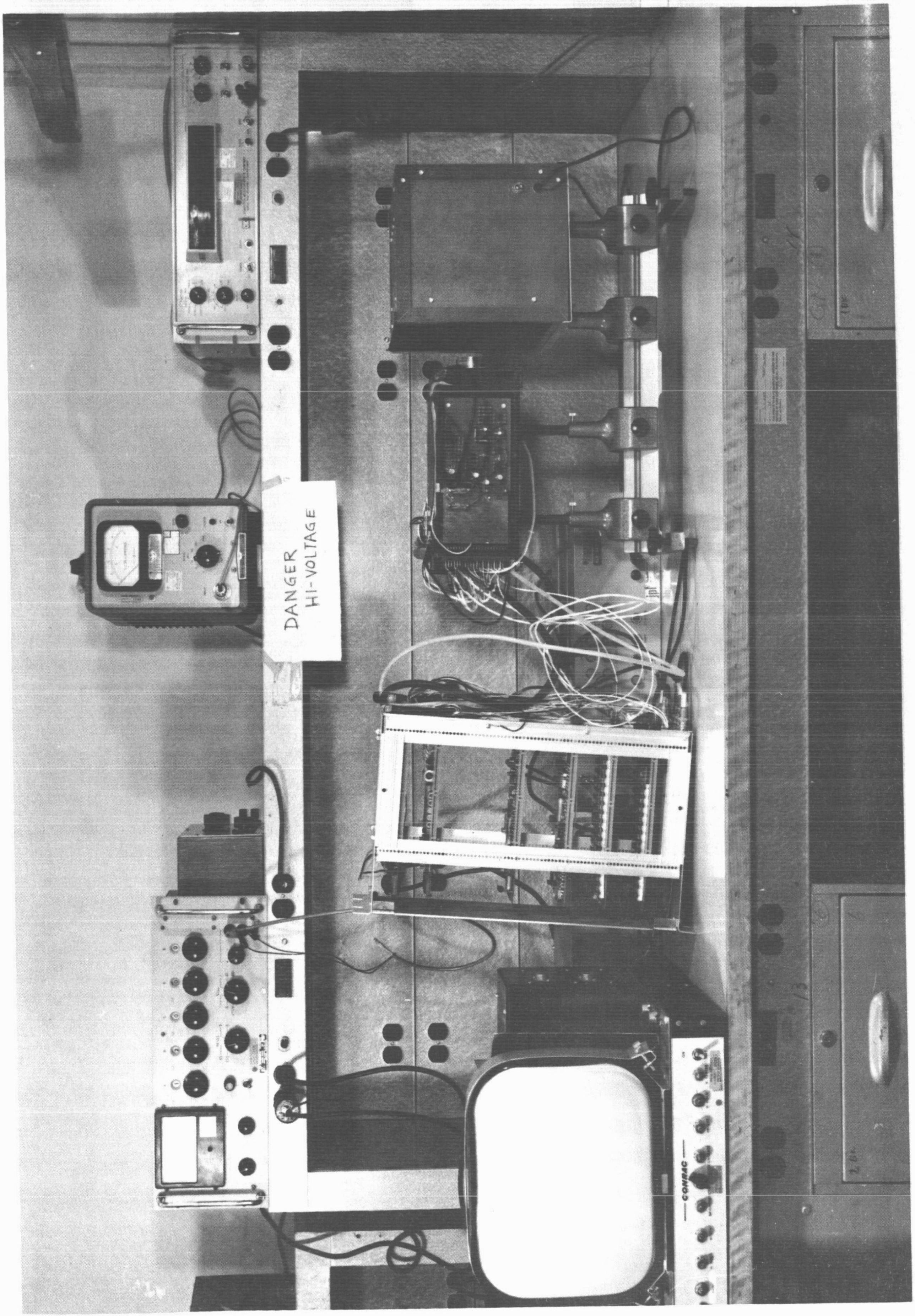


Figure 1   Ruggedized Imaging System Breadboard and Monitoring Equipment

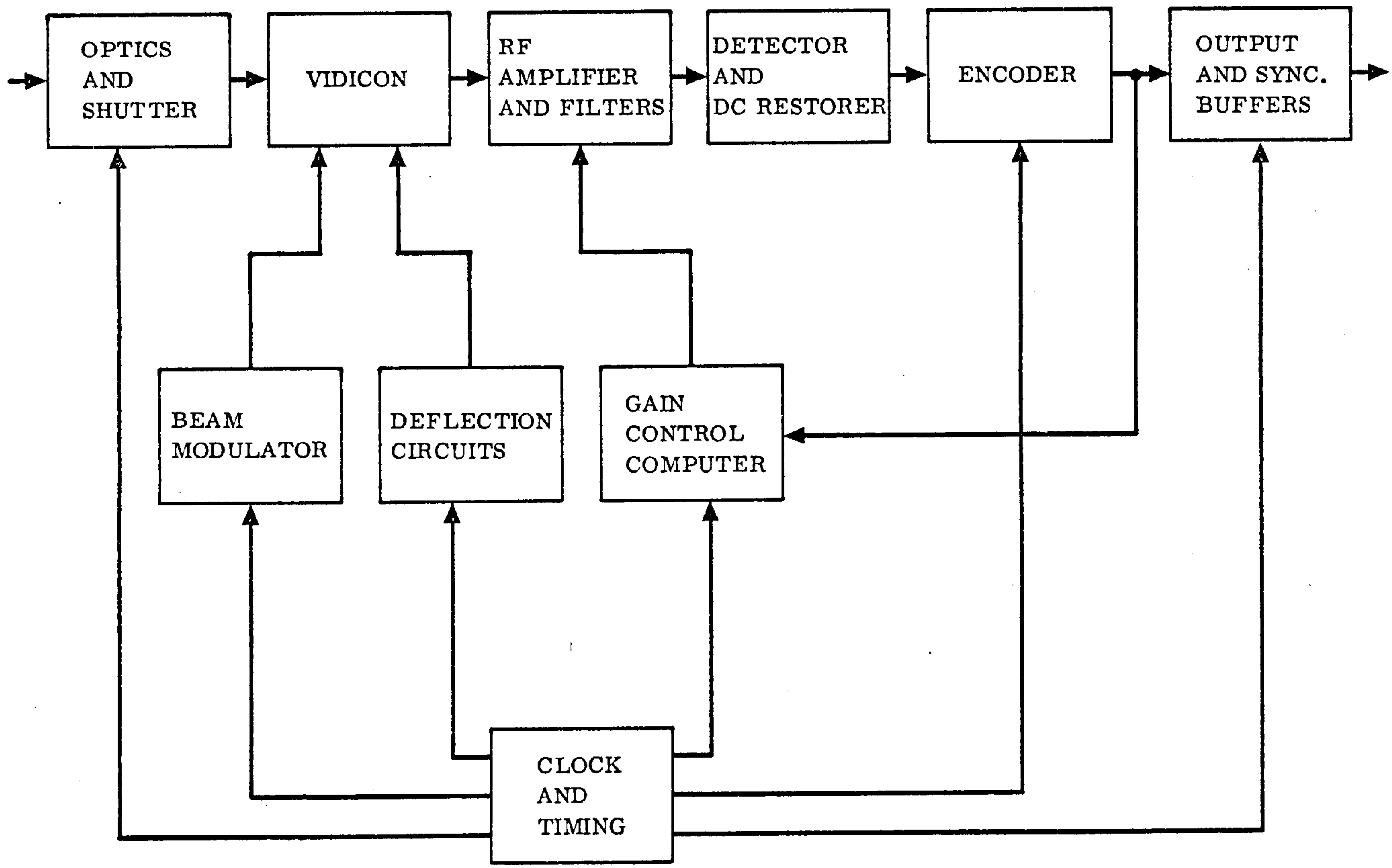
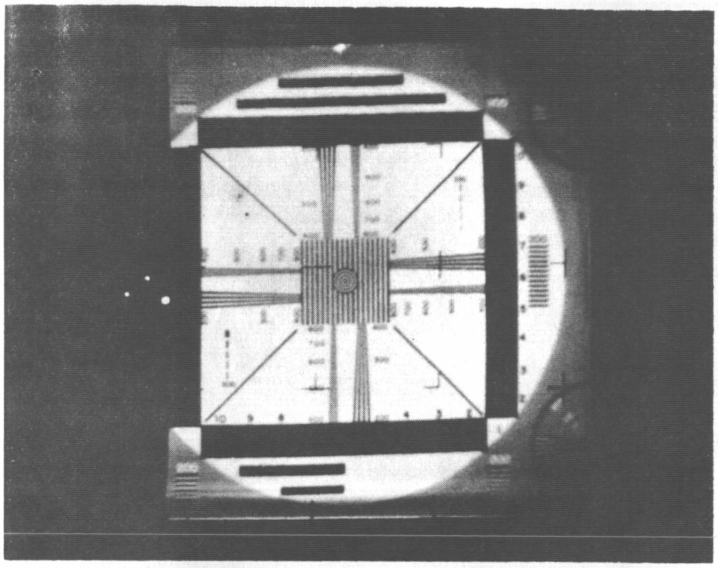
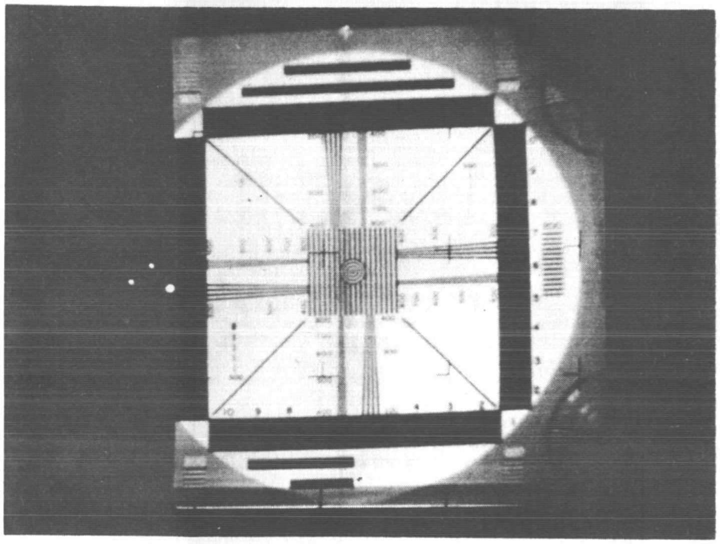


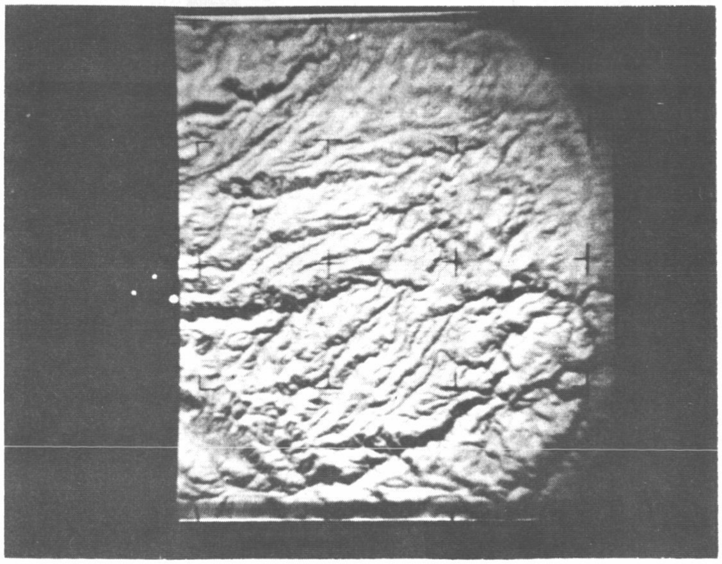
Figure 2 Functional Block Diagram



A. Monitor display with video input from the ruggedized imaging system's video detector output.



B. Monitor display with video input from the CONRAC D/A converter analog output. D/A converter input is the ruggedized imaging system PCM output.



C. Monitor display of a picture taken of a relief map slide. Video input to the monitor from the D/A converter output. D/A converter input is the ruggedized imaging system PCM output.

Figure 3 Photos of Monitor Display

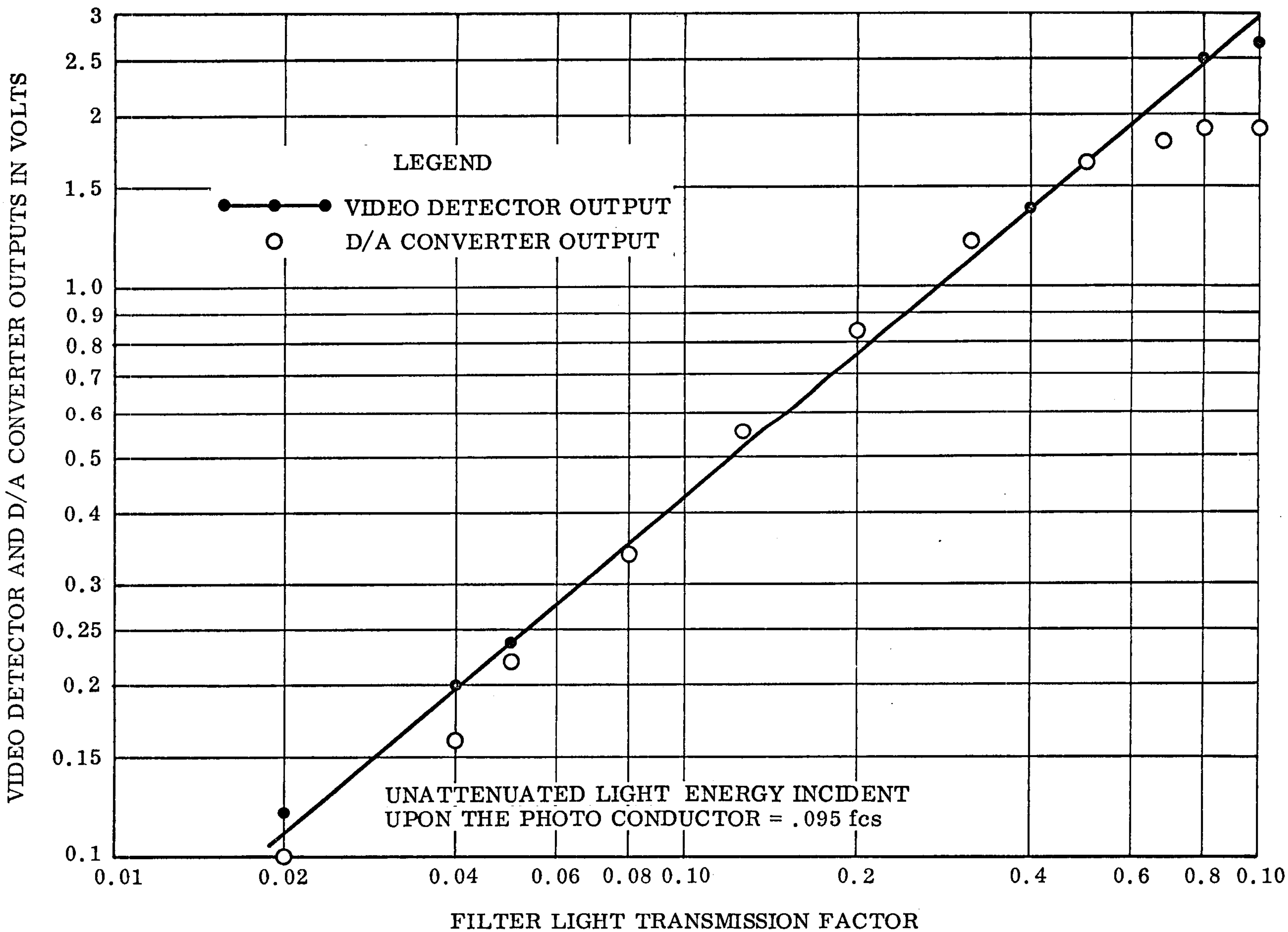
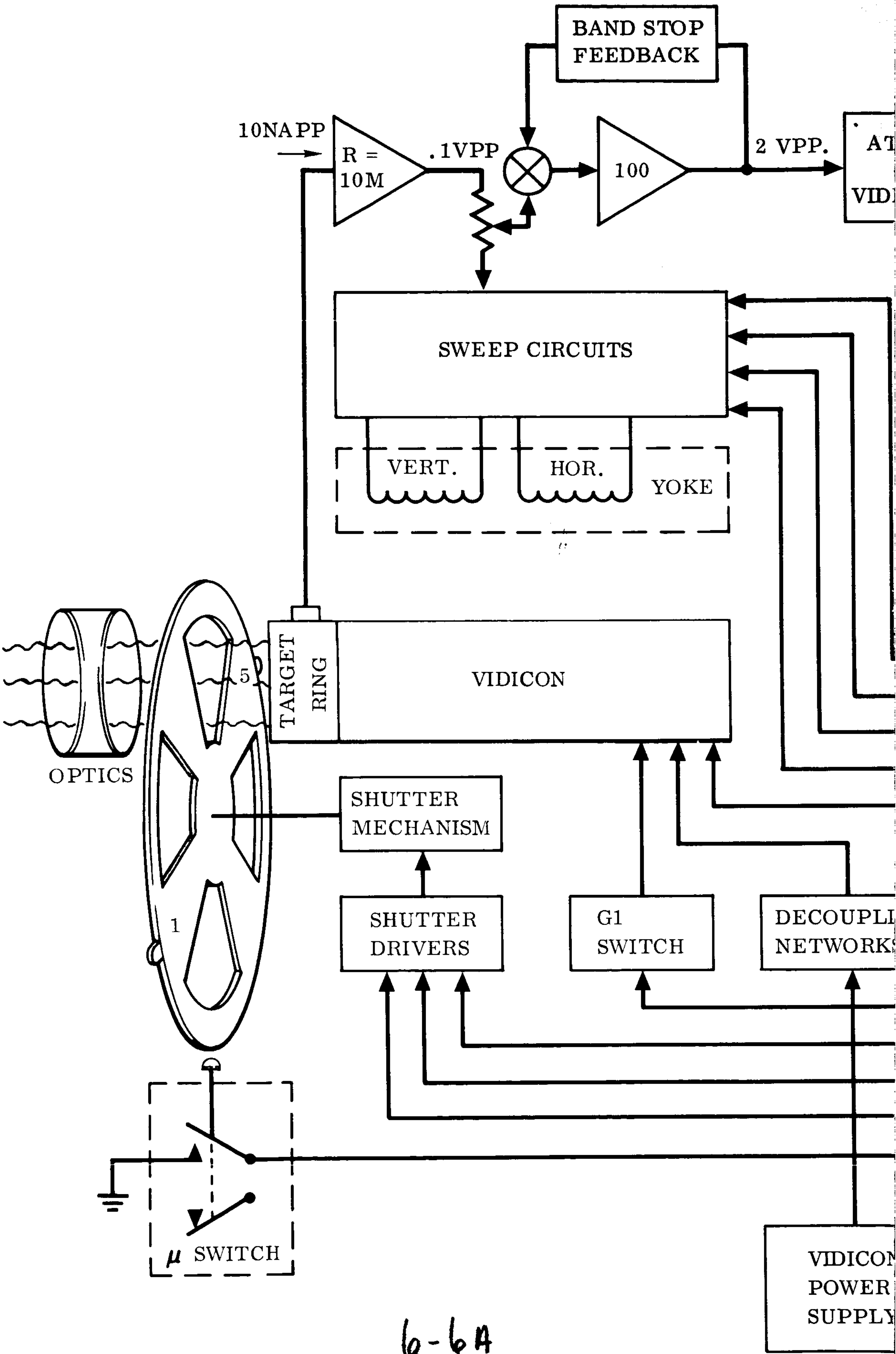
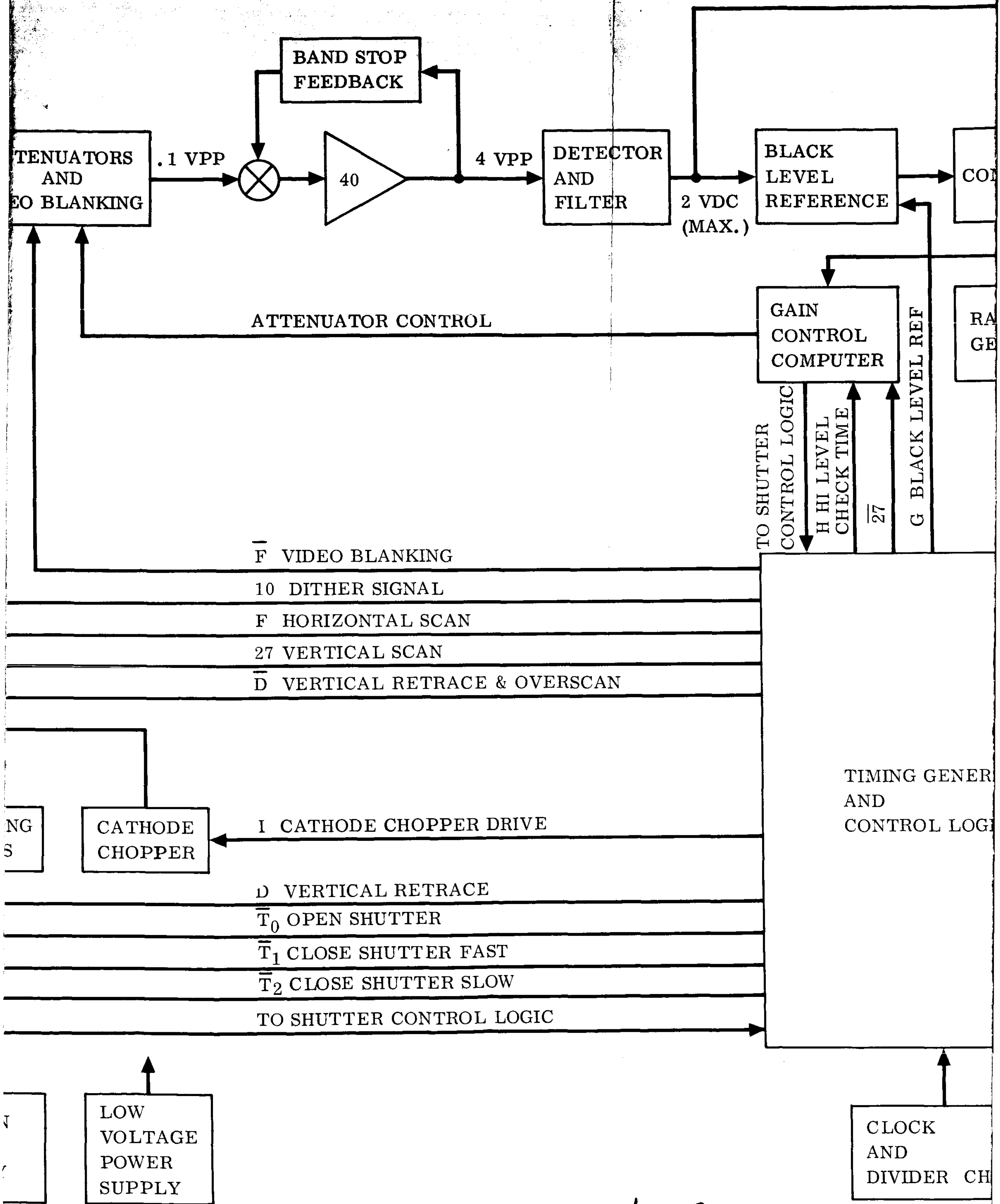


Figure 4 Transfer Characteristic



6-6A

FOLDOUT FRAME



6-6B

FOLDOUT FRAME

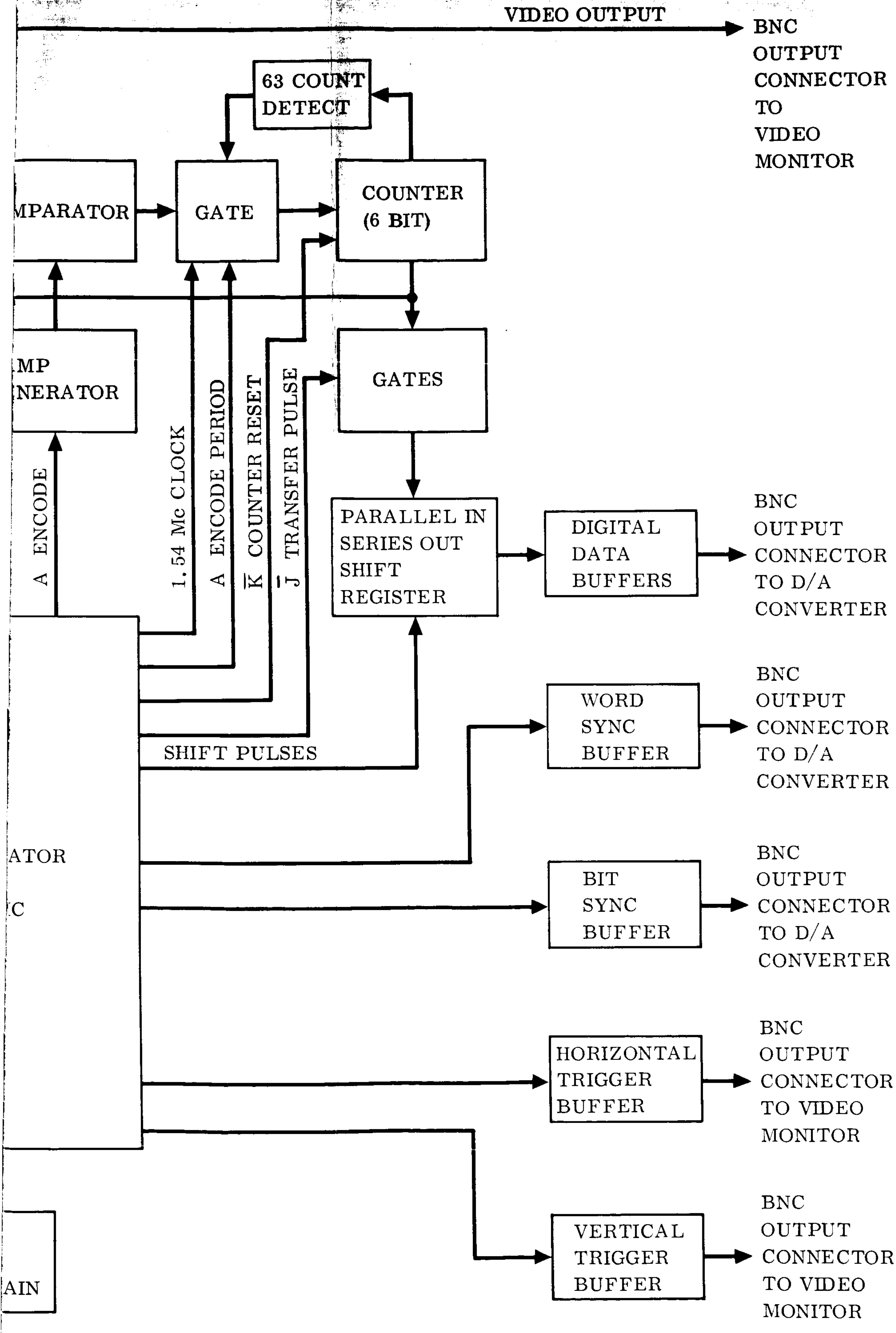


Figure 5 Detail Block Diagram

FOLDOUT FRAME

FREQ.	PERIOD	IDENT.	DIVIDE BY
1.536 mHz	.6510416··μs	1	1
768.0 KHz	1.3020833··μs	2	2
307.2 KHz	3.2552082·μs	3	5
153.6 KHz	6.5104166··μs	4	10
153.6 KHz	6.5104166··μs	5	10
76.8 KHz	13.020833··μs	6	20
38.4 KHz	26.04166··μs	7	40
19.2 KHz	52.0833··μs	8	80
9.6 KHz	104.166··μs	9	160
4.8 KHz	208.333··μs	10	320
2.4 KHz	416.666··μs	11	640
1.2 KHz	833.33··μs	12	1,280
600.0 Hz	1.666··ms	13	2,560
300.0 Hz	3.333··ms	14	5,120
150.0 Hz	6.666··ms	15	10,240

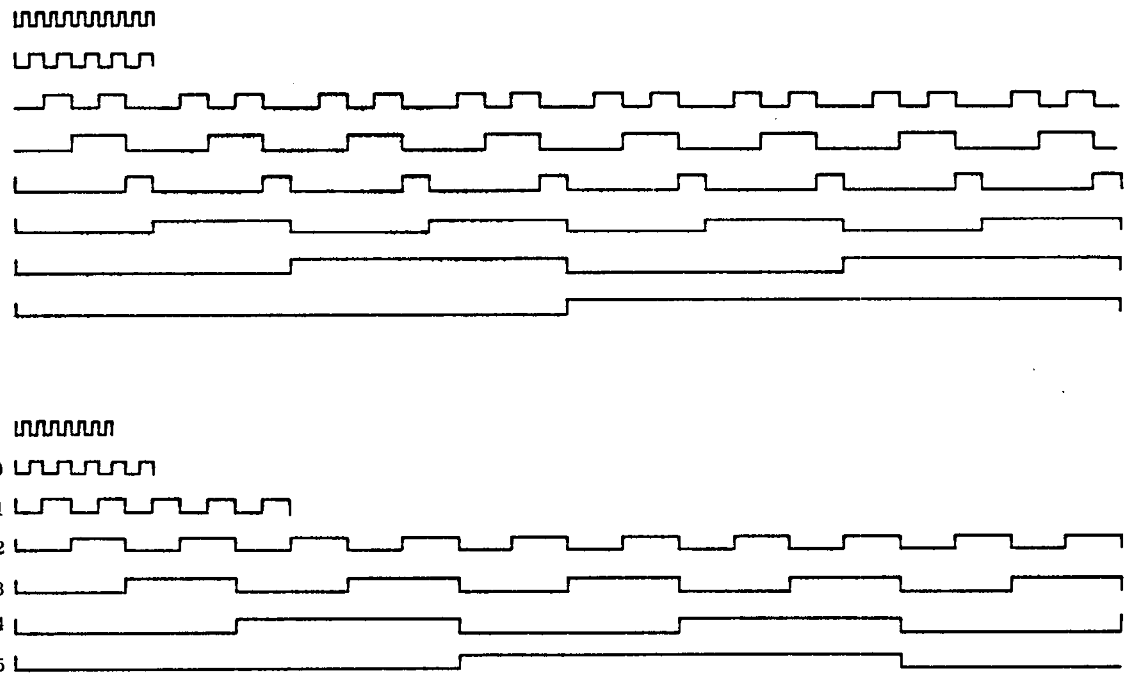


Figure 6A   Timing Chart

FREQ.	PERIOD	IDENT.	DIVIDE BY
75.0 Hz	13.333 - ms	16	20,480
37.5 Hz	26.666 - ms	17	40,960
18.75 Hz	53.333 - ms	18	81,920
9.375 Hz	106.66 - ms	19	163,840
4.6875 Hz	213.33 - ms	20	327,680
2.34375 Hz	426.666 - ms	21	653,360
1.171875 Hz	853.33 - ms	22	1,310,720
.5859375	1.7066 - s	23	2,621,440
.29296875	3.4133 - s	24	5,242,880
.146484375	6.8266 - s	25	10,485,760
.0732421875	13.6533 - s	26	20,971,520
.03662109375	27.3066 - s	27	41,943,040
.018310546875	54.6133 - s	28	83,886,080

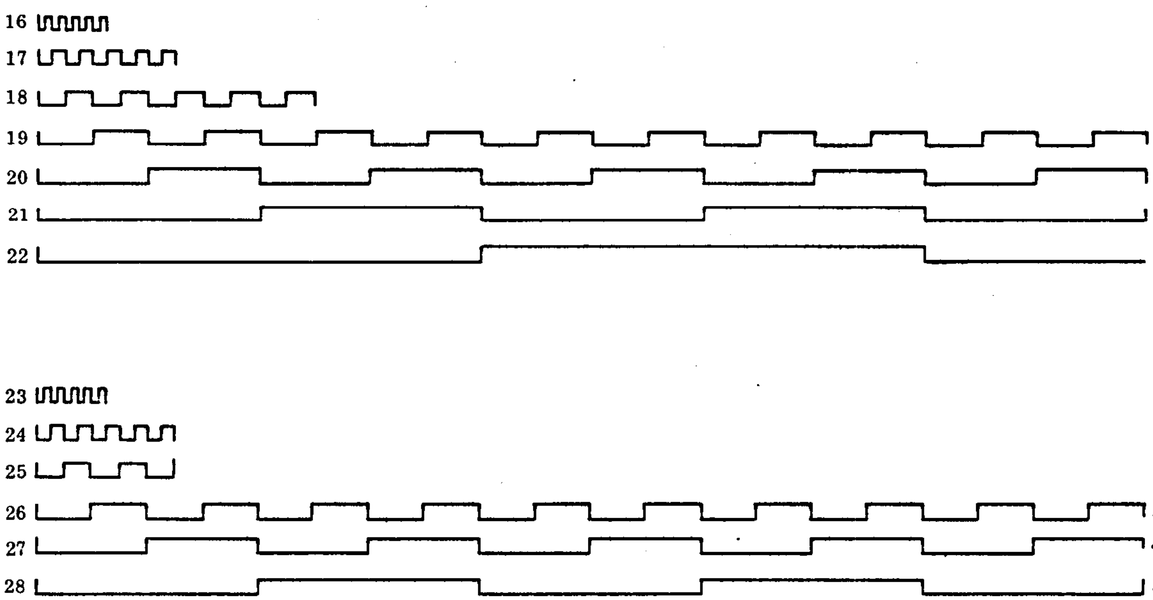


Figure 6B Timing Chart

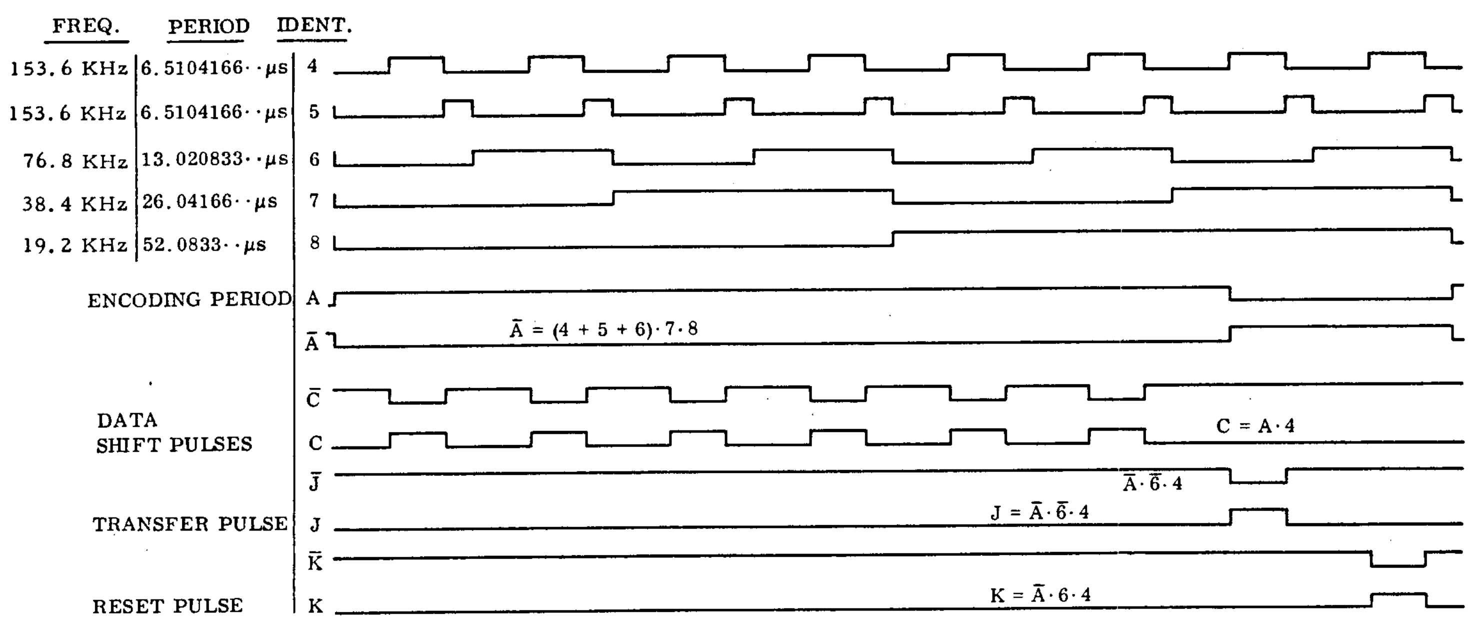


Figure 6C Timing Chart

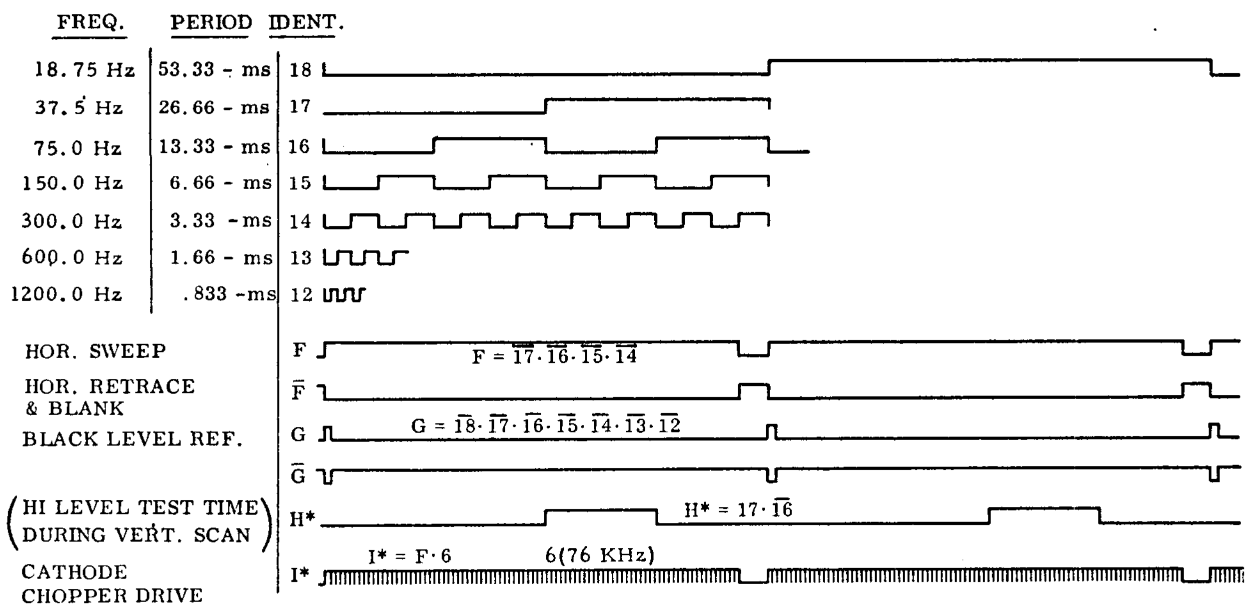


Figure 6D Timing Chart

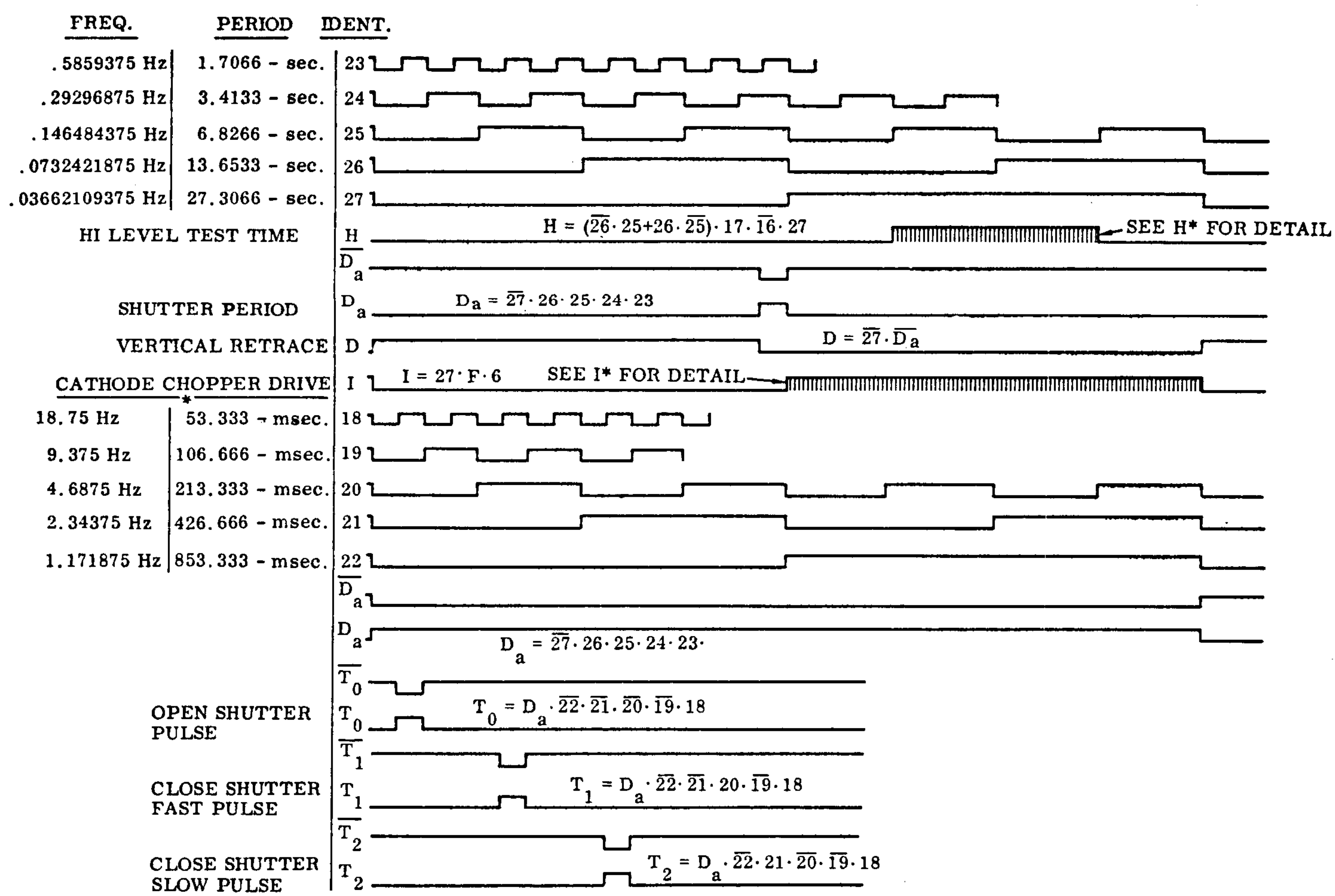


Figure 6E Timing Chart

Table 1

Tabulated Design Goals vs. Mariner C Imaging System Characteristics

	MARINER C IMAGING SYSTEM	RUGGEDIZED IMAGING SYSTEM
Scan lines per frame	200	512
Pixels per line	200	512
Frame time (sec)	24 sec	13.65
Active line time (m sec)	14.4	25
Beam chopper frequency KHz	110	76.8
Video base band KHz	7	10
Vidicon type	GEC 1343-010	RCA-C23086 (designed for) GEC-1343-010 used)
Focus	Electrostatic	Electrostatic
Scanning	Electrostatic	Electromagnetic
Scanned area mm square	5	11
Timing	composite free running	Synchronized
Circuitry	Separate block	Functionally integrated
Encoding rate RZPCM	1 mHz 6 bit	1.54 mHz 6 bit
Scanning	Analog	Analog
Volume in.^{3}	576	*400
Weight lb.	11.28	*9
Power w	8	*6

*Prototype design goals

APPENDIX A

STATEMENT OF WORK

SCHEDULE

ARTICLE 1 - STATEMENT OF WORK

(a) The Contractor shall, on a level of effort basis, provide not less than eighteen (18) nor more than twenty-two (22) man months of effort of engineering support in modifying existing Mariner C television camera electronics and electronic packaging at the Jet Propulsion Laboratory. For the purpose of this Contract, one (1) man month is defined as one (1) direct labor person performing assigned tasks for a period of one hundred seventy-three (173) direct straight time hours. This support effort shall include, but not be limited to:

(1) Modification of existing Mariner C television camera electronics and electronic packaging to utilize microelement circuitry.

(2) Redesign, fabricate, assemble and test at JPL, one (1) breadboard of a Mariner C television camera, utilizing microelement circuitry and exhibiting performance characteristics comparable to the existing Mariner C design.

(3) Evaluate "off the shelf" micro circuits as to their application.

(4) Breadboarding and testing of various modified circuits.

(5) Perform a review of the redesign of the television cameras. The major goal of this review shall be the full definition of those elements of the redesign specified in Article 1 (a) (2).

(6) Background Information - Ultimately, it is desirable to use the breadboard design as a basis for the packaging and fabrication of

a prototype camera system. The prototype design shall incorporate a JPL ruggedized vidicon imaging system. The design goal is for the prototype camera system to be capable of meeting the following environment requirements:

(i) Static Acceleration: ±190 g, 20 minutes in each of three (3) orthogonal directions.

(ii) Vibration: All of the following shall be performed along each of three (3) orthogonal directions.

(A) Sinusoidal vibration swept at 0.5 octave per minute.

±0.5 in displacement	5-17 Hz
5 g rms	17-50 Hz
15 g rms	50-100 Hz
35 g rms	100-200 Hz

(B) Wide band noise, 25 g rms, 9 minutes duration, 15-2000 Hz.

(iii) Shock: All of the following shall be performed five (5) times in each direction along each of three (3) axes.

A) ±200 g terminal peak saw tooth, 0.5 ms rise time.
B) ±150 g terminal peak saw tooth, 5 ms rise time.
C) ±3000 g modified square wave 0.1 ms rise time, 3 ms duration, 0.1 ms fall time.

(iv) Thermal/Vacuum

A) 12 days at 75^{o}C and 10^{-6} torr.
B) 4 days at -10^{o}C and 10^{-6} torr.
C) The prototype camera shall be capable of surviving the sterilization specification as outlined in VOL-50503-ETS dated 12 January 1966.

(7) Provide the following documentation:

(i) Technical

A) Monthly Progress Report
B) Final Summary Progress Report
C) All Drawings
D) Test Procedures
E) Test Results
F) Failure Reports
G) Material Reports
H) Electronic Components List
I) Operating and Maintenance Manual

(ii) Administrative

A) Monthly Status and Cost Report
B) Monthly Status and Cost Report Summary
C) Monthly Cost Report, JPL 0330

(8) Conform to the following conditions of operation:

(i) Overall management of the facilities is the responsibility of the Jet Propulsion Laboratory. Supervision of Contractor personnel shall be the responsibility of the Contractor.

(ii) Upon execution of this Contract, an on-lab supervisor is to be appointed by the Contractor from the direct labor listed herein to be responsible for the direction of all Contractor personnel.

(iii) The Contractor shall maintain for assignment to the effort sufficient personnel with competence levels as follows:

Category 1: <u>Design Specialist</u>

Minimum requirement - Degree. Five (5) years' experience in solid state circuit design and preferably in the microelectronics field.

Category 2: <u>Associate Engineer</u>

Minimum requirement - Degree. Two (2) years' experience in solid state electronics, preferably in the microelectronics field.

Category 3: <u>Technician</u>

Two (2) years experience in fabrication and testing of solid state electronics, preferably in microelectronics field.

(iv) The Contractor shall be responsible for selecting personnel who are well qualified to perform the required work, subject, however, to the initial and continuing approval of JPL. JPL, through its cognizant Contract Negotiator, may, if it finds it to be in its best interest, direct the Contractor to remove or replace any Contractor employee or employees assigned to this effort and the Contractor shall forthwith comply with such direction.

(v) The Contractor shall not remove or replace personnel approved by JPL and assigned to this program without written permission from JPL.

(vi) The work day shall begin upon arrival of personnel at JPL and shall terminate upon their departure therefrom. Notwithstanding the above, Contractor personnel may occasionally be expected to work unusual hours for extended periods of time at no increase in fee to the Contractor.

(vii) All Contractor personnel shall be governed by JPL safety regulations and operational procedures.

(viii) Security clearances to a level of CONFIDENTIAL shall be provided by the Contractor for all Contractor personnel assigned to this effort. When required by JPL, clearances of higher classifications shall be provided.

(ix) The provisions of ARTICLE GP-17, GOVERNMENT PROPERTY, to the contrary notwithstanding, it is understood and agreed that the responsibility for maintaining records for the control of Government property and the accountability for such property from a record control standpoint shall be in JPL, and the Contractor is not required to maintain any records as required by NPC 105, NASA Industrial Property Control Manual. It is agreed, however, that the provisions of this paragraph shall in no way relieve the Contractor of liability for loss or damage to Government property as provided in paragraph (f) of ARTICLE GP-17, GOVERNMENT PROPERTY.

(b) JPL will make available:

(1) All computer time deemed necessary by the JPL Technical Representative for equipment checkout at JPL.

(2) Technical assistance deemed necessary by the JPL Technical Representative to Contractor personnel.

(3) Necessary tools, equipment and Laboratory facilities needed for the performance of the effort set forth herein.

APPENDIX B

REPORT ON PRELIMINARY DESIGN REVIEW OF THE HYPER-RUGGEDIZED IMAGING SYSTEMS ELECTRONICS

13 June 67
CFC

Report on Preliminary Design Review of the

Hyper-Ruggedized Imaging System Electronics

On May 9, the Design Review Team met with representatives of the study contractor, Ryan, to review the results of their Phase I activities. The objectives of the program are delineated in Attachment "A."

Detailed descriptions were presented of the block diagrams and circuit diagrams. Most of the elements of the system had been breadboarded and tested.

The block diagram of the complete system showed no provision for external control of the camera functions as, for example, override of the automatic gain control or selection of shutter speeds. The environmental temperature range and extremes for which the circuitry is being designed are good. However, if designing for operation at 25° C $\pm$ 75° C entails some sacrifice in performance, it may be desirable to relax this requirement and rely on a temperature control system to maintain operating temperatures. It should be noted that other elements of a landed spacecraft system are not likely to be designed for this large range of temperatures. It was stated that a synchronized system was developed using oscillators without crystals because crystals are difficult to make cope with high temperature and high shocks.

The two major factors which differentiate this system from other previous space instrument systems are the sterilization and high impact requirements. The apparently rather subjective evaluation of the effect of the sterilization temperature cycles on transformers, and the lack of any detailed evaluation of sterilization effects on other components leads one to the conclusion that not enough attention is being given to the need to meet this requirement. At no time was discussion of the subject brought forth by the representatives from Ryan Electronics. Whenever the question of sterilization was raised, it was quickly put back to bed with one of two answers: (1) the published literature had been read, or (2) a new generation of components is being used and proof of sterilizability cannot catch up with the state-of-the-art. There is no need to wait for information to be published. The Component Evaluation Group here at JPL and component manufacturers can provide a considerable amount of information. However, there is little information now available on the effects of sterilization on integrated circuits. This should be evaluated before they are utilized.

During the remainder of the program, more consideration should be given to the sterilization requirement. Neglect at this time can result in considerable wasted effort and redesign later in the program.

Aside from the off-hand remark concerning the ability of crystals to withstand shock, no consideration has apparently been given so far to the structural and mechanical aspects of packaging these electronics for survival of high impact shock.

The electronics block diagram was similar to that of the Mariner IV camera and, as such, should involve only a few difficult circuit design problems. There is included in the circuit diagrams, a mix of integrated and discrete components. Subject to the previous comment regarding the lack of information on sterilizability of integrated circuits, additional effort should be expended to reduce the amount of discrete component circuitry. The relatively large variety of integrated circuit types imposes a requirement for a large number of different power supply voltages. This may result in a lower reliability and efficiency.

The following potentially troublesome areas were noted in examining circuit design details:

a. How much magnetic shielding will be required for the vidicon yoke, and what is allowable residual magnetic field? (Presently undefined.)

b. Active twin-tee filters may introduce undesirable ringing to steep wavefronts because of non-linear phase-shift characteristics. Suggest either Bessel, or Butterworth-Thompson form.

c. Active filter bandpass may show undesirable temperature sensitivity.

d. Does 1.536 MC clock incorporate "sure-start" circuitry, to preclude a lock-up at low-temperature?

e. Are vertical deflection drivers (2N2222 and 2N722) adequately derated for peak collector dissipation?

f. Can baseband video recovery be improved by utilizing synchronous detection?

These areas require further investigation prior to design of the prototype.

Recommendations

It is recommended that the two major critical areas, sterilization and high impact shock, be given considerably more attention if the program objectives delineated on Attachment "A" are to be met. Specifically, the ability of each material,component and potential assembly of the system to withstand the sterilization procedures should be examined and a circuit design evolved utilizing only components known to be capable of surviving these. The shock survival capabilities of components and assemblies are too dependent upon packaging to be independently assessable. It is therefore recommended that packaging design criteria be prepared for the shock survival requirement.

The total environmental requirement problem could be dealt with more meaningfully in the context of a hypothetical mission and system application. It is recommended that at least one such hypothetical mission be assumed and the consequent environmental requirements defined for this study.

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APPENDIX C

RYAN RESPONSE TO PRELIMINARY DESIGN REVIEW REPORT

APPENDIX C

Ryan Response to Preliminary Design Review Report, (Appendix B)

The comments from the Design Review Board on the Ruggedized Imaging System are appreciated. Where possible the recommendations of the board were followed. The answers to technical questions which could not be fully provided at the time of the design review are given in this appendix.

Additional work was recommended by the design review board in the critical areas of sterilization and high impact shock. Ryan agrees with this recommendation. During Phase 1 of this program, time was not allotted to Ryan to do a detailed study on effects of sterilization and shock on electronic parts. The parts used were selected from the JPL Electronic Part Sterilization Candidate List, ZPP-2010-SPL-C, where possible. In many cases the part required for a state of the art circuit design did not appear on this list. In these cases the part was selected from the JPL Preferred Parts List, the Ryan Space Projects Preferred Parts List or the best available data. The Ryan Reliability Group was consulted heavily on selection of parts. Frequent contact was also made with the JPL reliability group.

The major portion of the design effort to withstand high impact shock will be concentrated in the prototype design phase of this program. The requirement to withstand high shock environment was strongly considered in the selection of circuit type and electronic parts. Massive items such as transformers, inductors, and large capacitors were replaced by equivalent electronic circuitry where feasible. Component size was held to a minimum to reduce moments. Exploratory work is continuing in house at Ryan to develop microcircuit hybrids of typical digital and analog circuits used in the Ruggedized Imaging System, in order to reduce the number of discrete parts which must be supported against high impact. Testing of these hybrids is in progress as of this writing.

It was stated that little information about the effects of sterilization on integrated circuits was available, and that they should be evaluated before they are utilized. It is true that more information is desirable, however, a report by JPL's John Visser states that after 8000 hours of testing, "Statistical analysis to date has resulted in no significant failure modes due to heat sterilization." The observed failures were the result of poor quality control and inadequate screening tests. Available information indicates that integrated circuits will meet the sterilization requirement but the enforcement of good quality control and screening procedures will be essential.

Two other comments were made about the use of integrated circuits. One was that more effort should be expended to reduce the amount of discrete components circuitry, and the other expressed concern because a large variety of integrated circuit types imposes a requirement for a large number of different power supply voltages. While there are a number of voltages developed, most of them are required by the vidicon. The circuitry requirement is only +5 vdc for the great majority of the digital integrated circuits, and ±6 vdc and ±12 vdc for the rest of the circuits. This number of supply voltages is not unusual for systems of this size. Additionally, because the greatest load current demand can be supplied from the ±6 vdc supplies, but ±12 vdc is required by much of the circuitry, efficiency is increased by using both ±6 vdc and ±12 vdc. Although it is desirable to implement more functions with integrated circuits, and every effort was made to do so, those in the breadboard were the only ones available which could be efficiently used. Unless other integrated circuits are developed and made commercially available, or existing proprietary custom developed integrated circuits released for open sale, hybrid circuits offer the only expedient means to further miniaturize the system.

The following specific questions were listed in the design review report. Answers are given following each question.

a) How much magnetic shielding will be required for the vidicon yoke, and what is allowable residual magnetic field: (Presently undefined.)

The magnetic shielding requirements are not yet known since the allowable field is not defined.

b) Active twin-tee filters may introduce undesirable ringing to steep wavefronts because of non-linear phase-shift characteristics. Suggest either Bessel, or Butterworth-Thompson form.

A moderate amount of ringing at the resonant frequency does occur in the band pass filters when steep wave front step functions are applied as would be expected. The Q of the filters are low, however, and the ringing damps quickly. There are no high frequency ringing components which would affect the operation when a 76 KC square wave is applied.

c) Active filter bandpass may show undesirable temperature sensitivity.

Detail temperature test data was not taken on the frequency stability of the active bandpass filters. The overall gain of the bandpass amplifiers was checked over temperature and found to have good stability. Experience on similar active filter circuits at Ryan has indicated that the frequency stability can be held within the practical limit of component tolerances. Frequency stability of ±2% is achieved over a $-50^{o}C$ to $+80^{o}C$ range in an item of military hardware produced by Ryan.

d) Does 1.536 MC clock incorporate "sure-start" circuitry, to preclude a lock-up at low temperature?

The clock circuit does employ a "sure start" circuit to insure turnon under all conditions. Temperature testing over the range of $-50^{o}C$ to $+100^{o}C$ was performed to confirm reliable operation of this circuit.

e) Are vertical deflection drivers (2N2222 and 2N722) adequately derated for peak collector dissipation?

The 2N2222 and 2N2907 vertical deflection drivers were used in the breadboard with convective cooled heat sinks as a substitute for types 2N2219 and 2N2905 which will be called out for the final package.

f) Can baseband video recovery be improved by utilizing synchronous detection?

The use of a synchronous, or coherent detector, rather than the envelope detector may improve the signal-to-noise ratio from 1 to 3 db, over the range of signal-to-noise ratios of interest. In order to obtain this improvement, however, the relative phase shift of the signal must be carefully controlled through the amplifiers and filters. It is not believed at this time, that the potential signal-to-noise improvement warrants the additional complications imposed by a synchronous detector.

APPENDIX D

BOARD LAYOUT PHOTOGRAPHS
AND
LIST OF COMPONENT PARTS

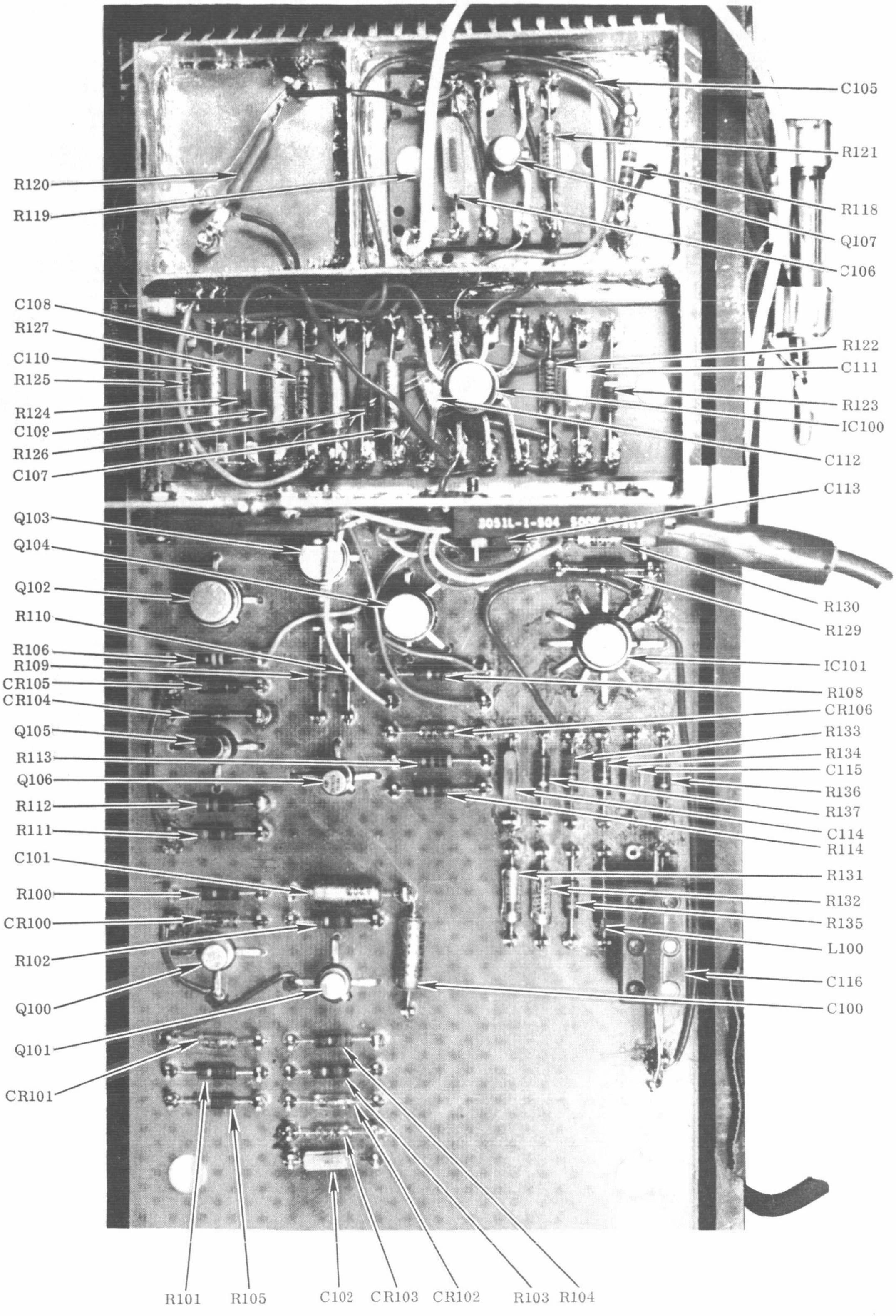


Figure D-1 Top View Board 1 Preamp, G1 Switch, Cathode Chopper

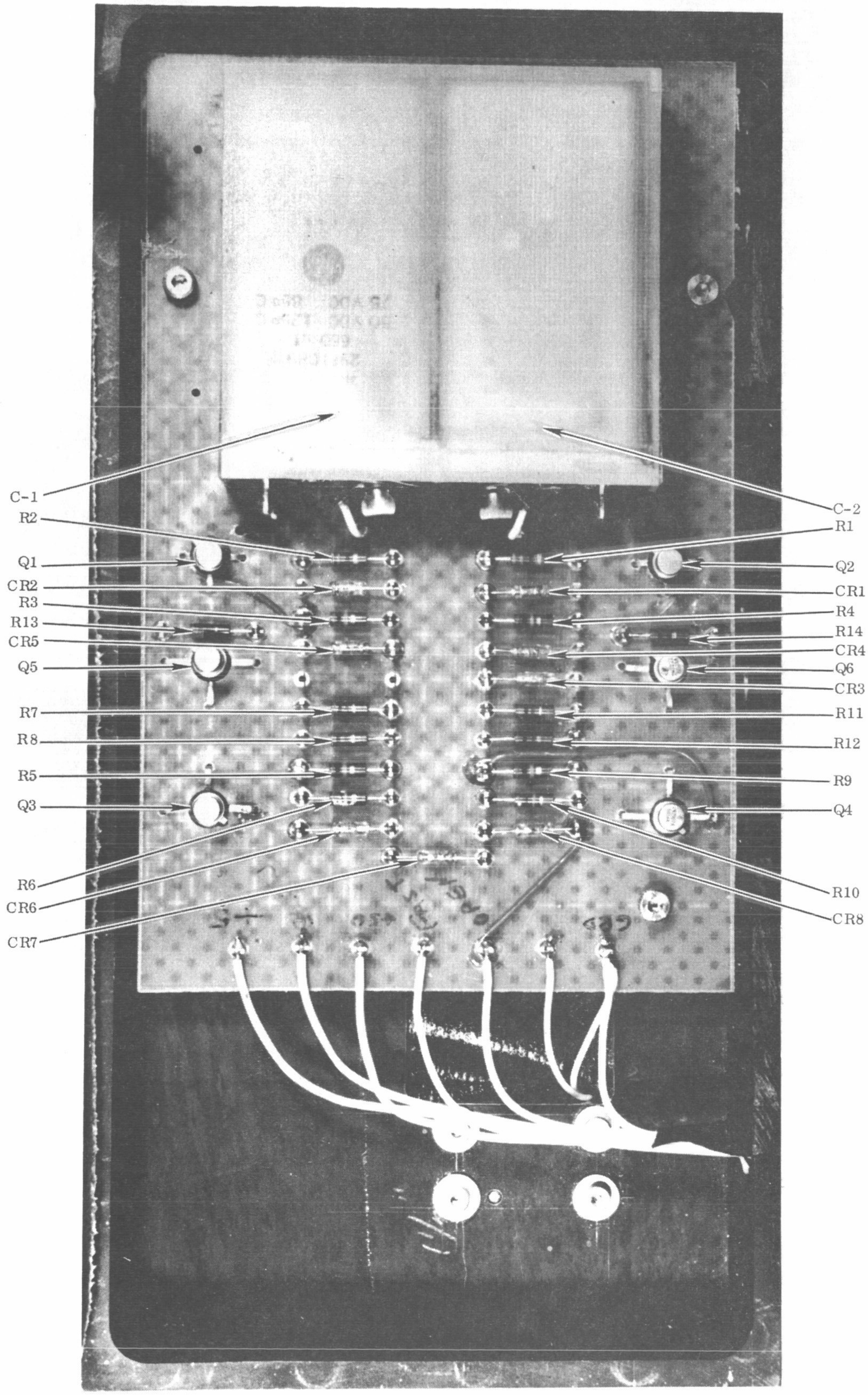


Figure D-2 Top View Board 1A Shutter Drive

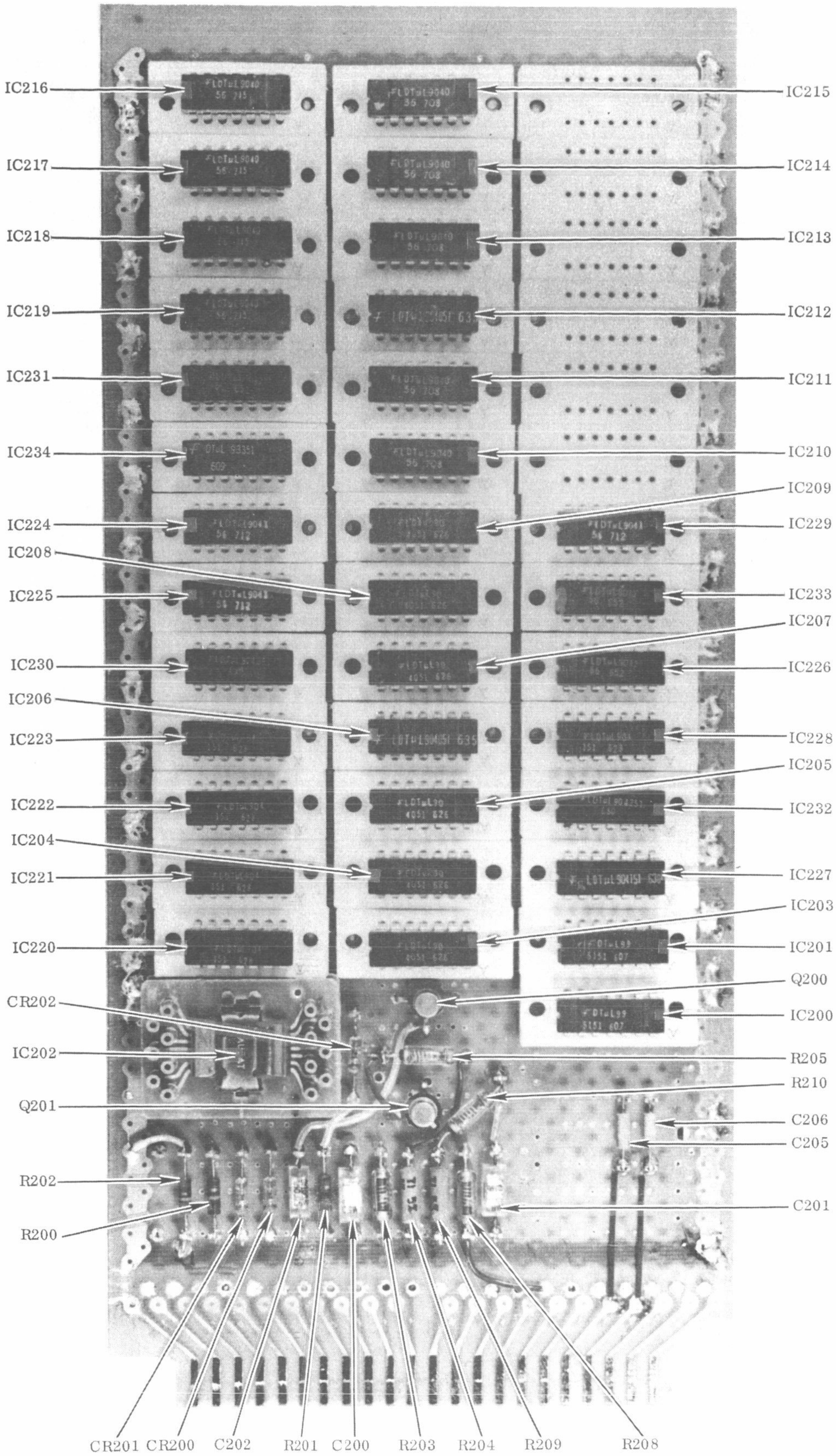


Figure D-3 Top View Board 2 Timing and Control

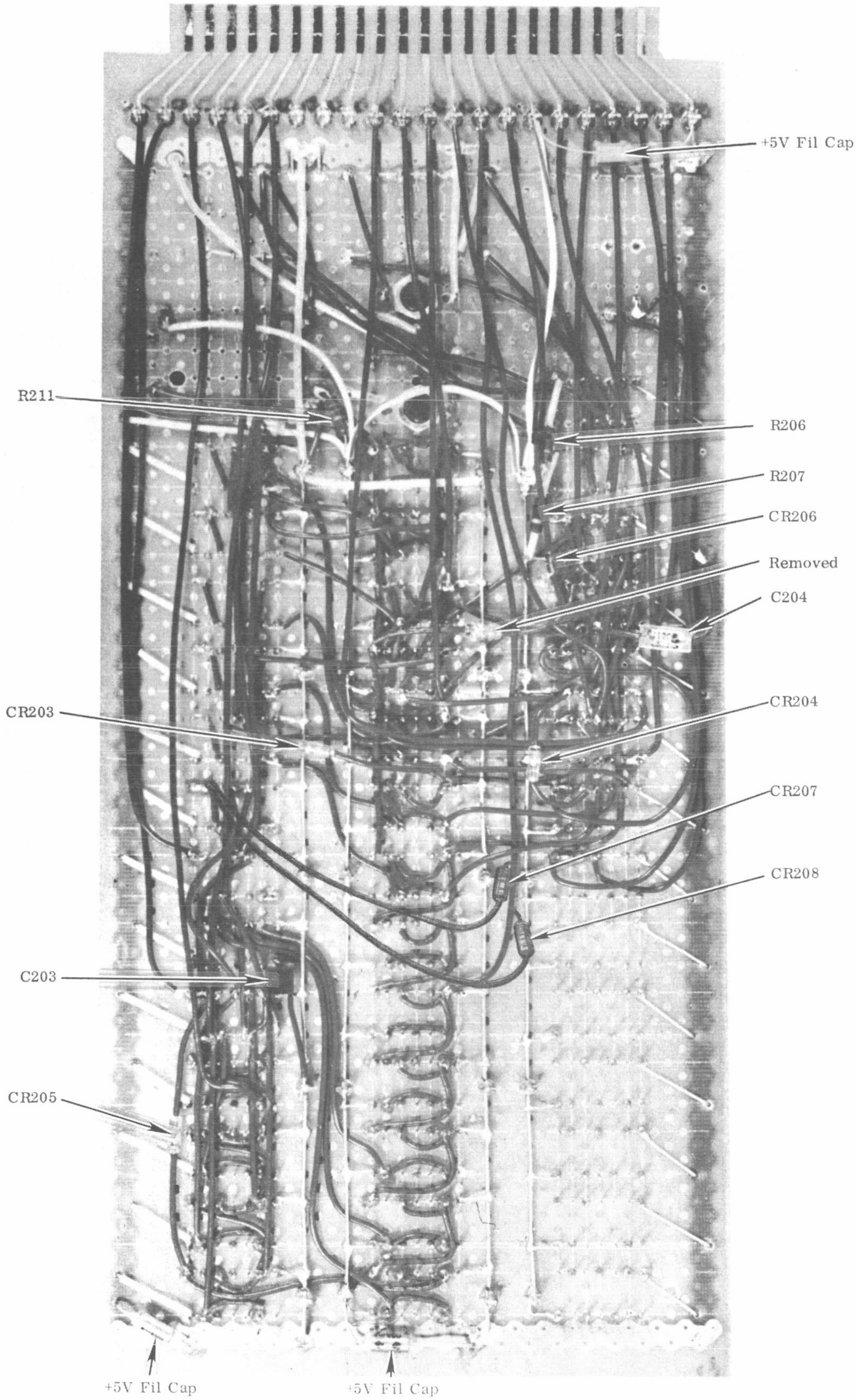


Figure D-4 Bottom View Board 2 Timing and Control

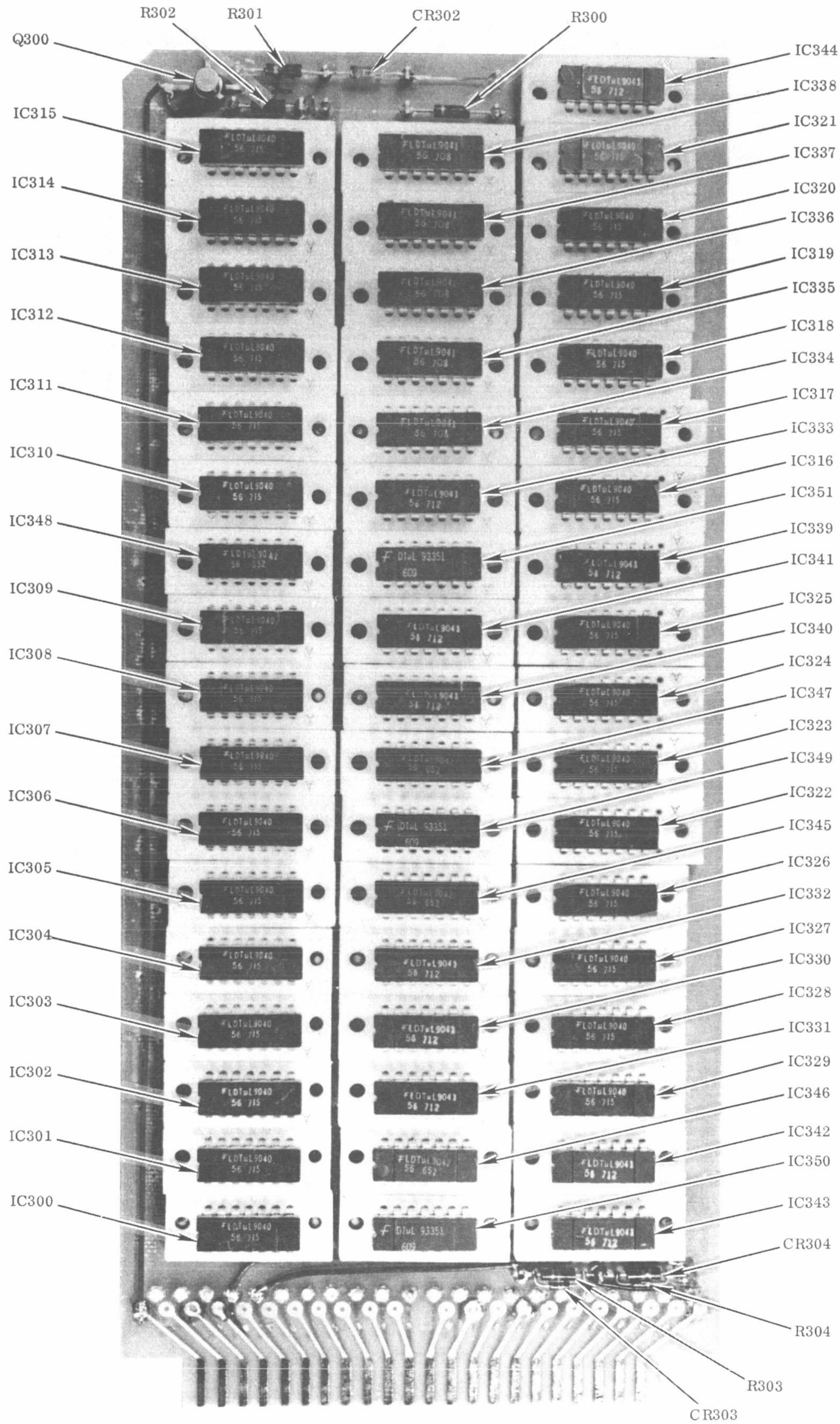


Figure D-5 Top View Board 3 Timing and Control

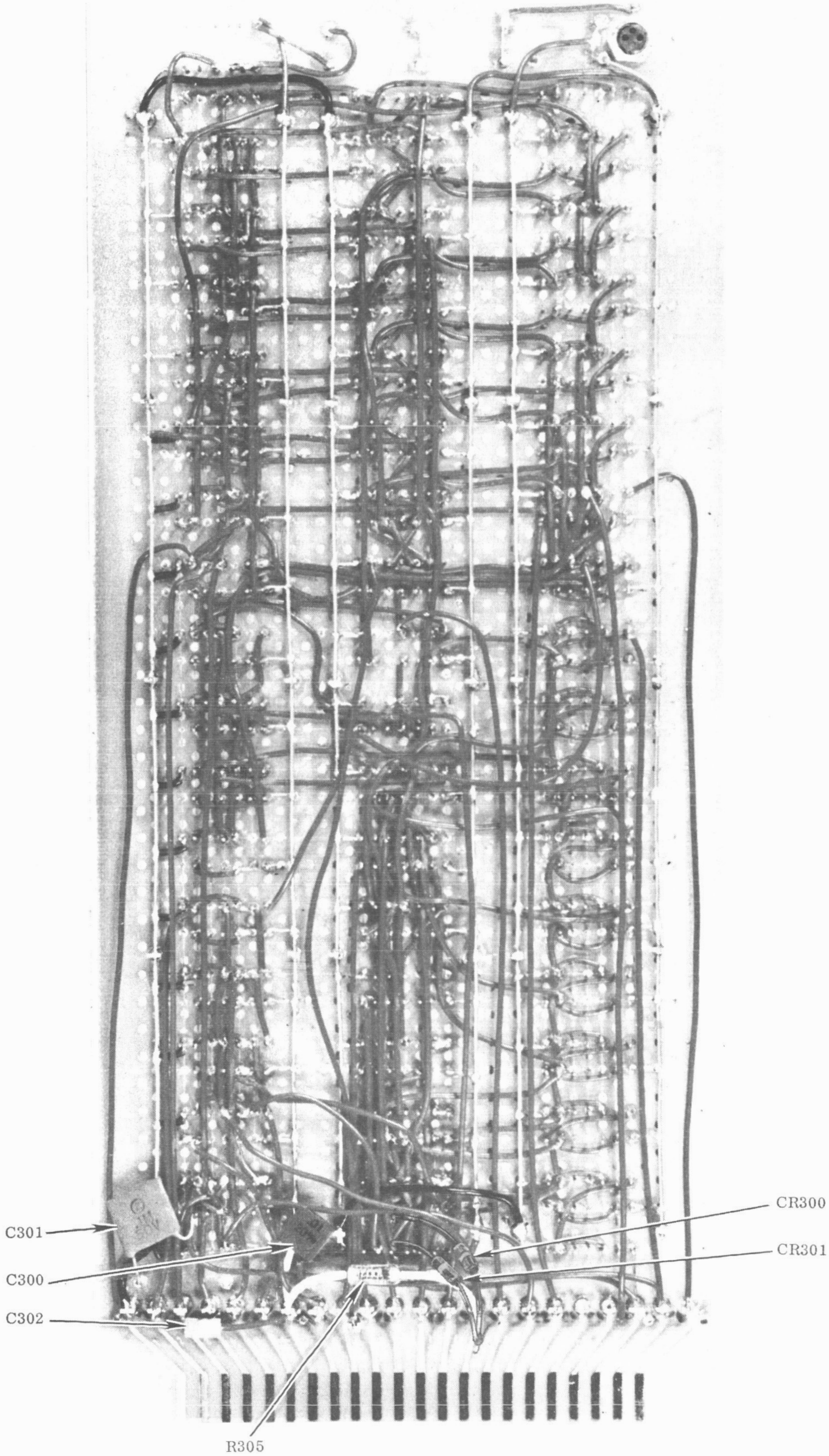


Figure D-6 Bottom View Board 3 Timing and Control

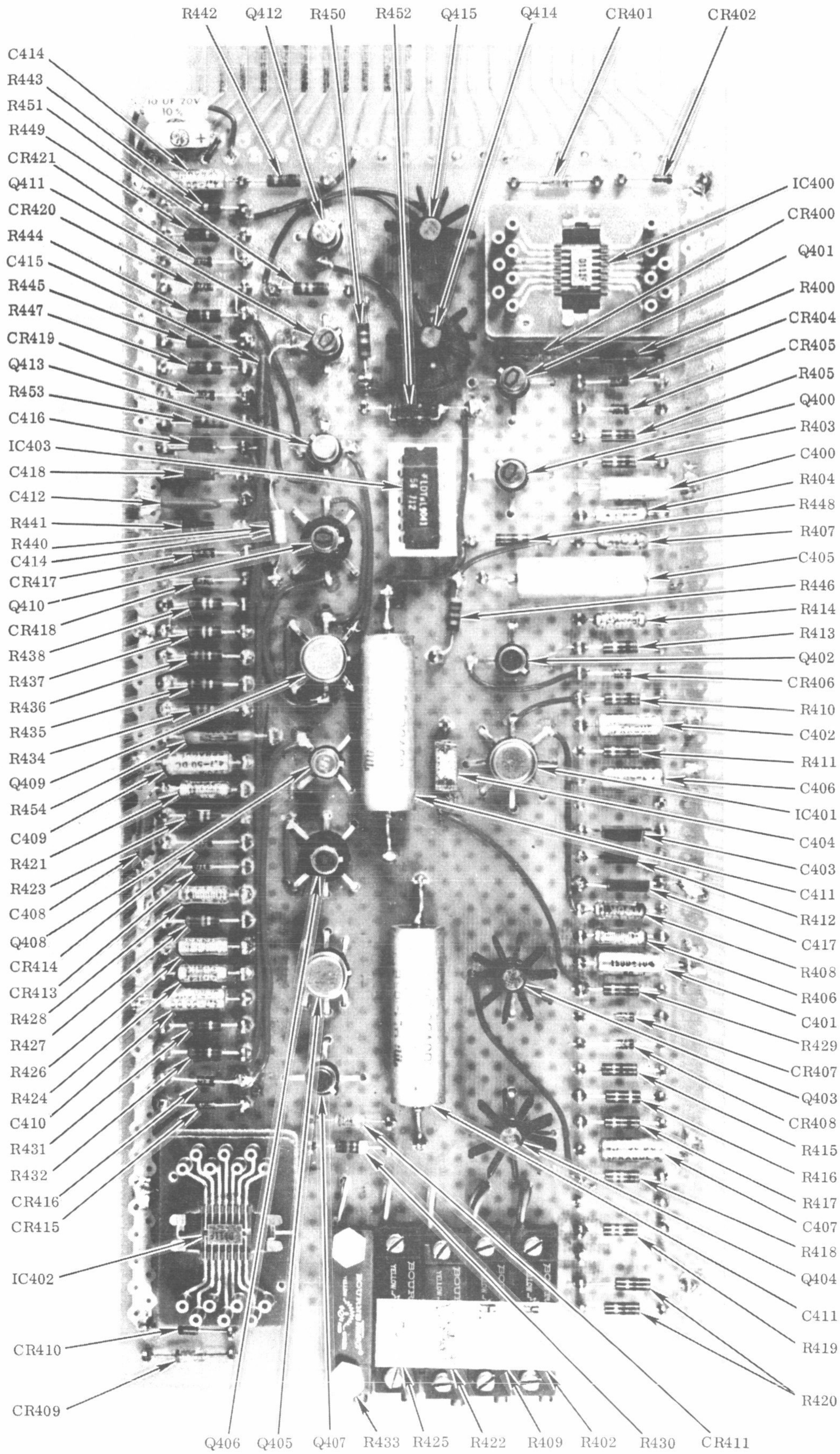


Figure D-7 Top View Board 4 Horizontal and Vertical Sweep Circuits

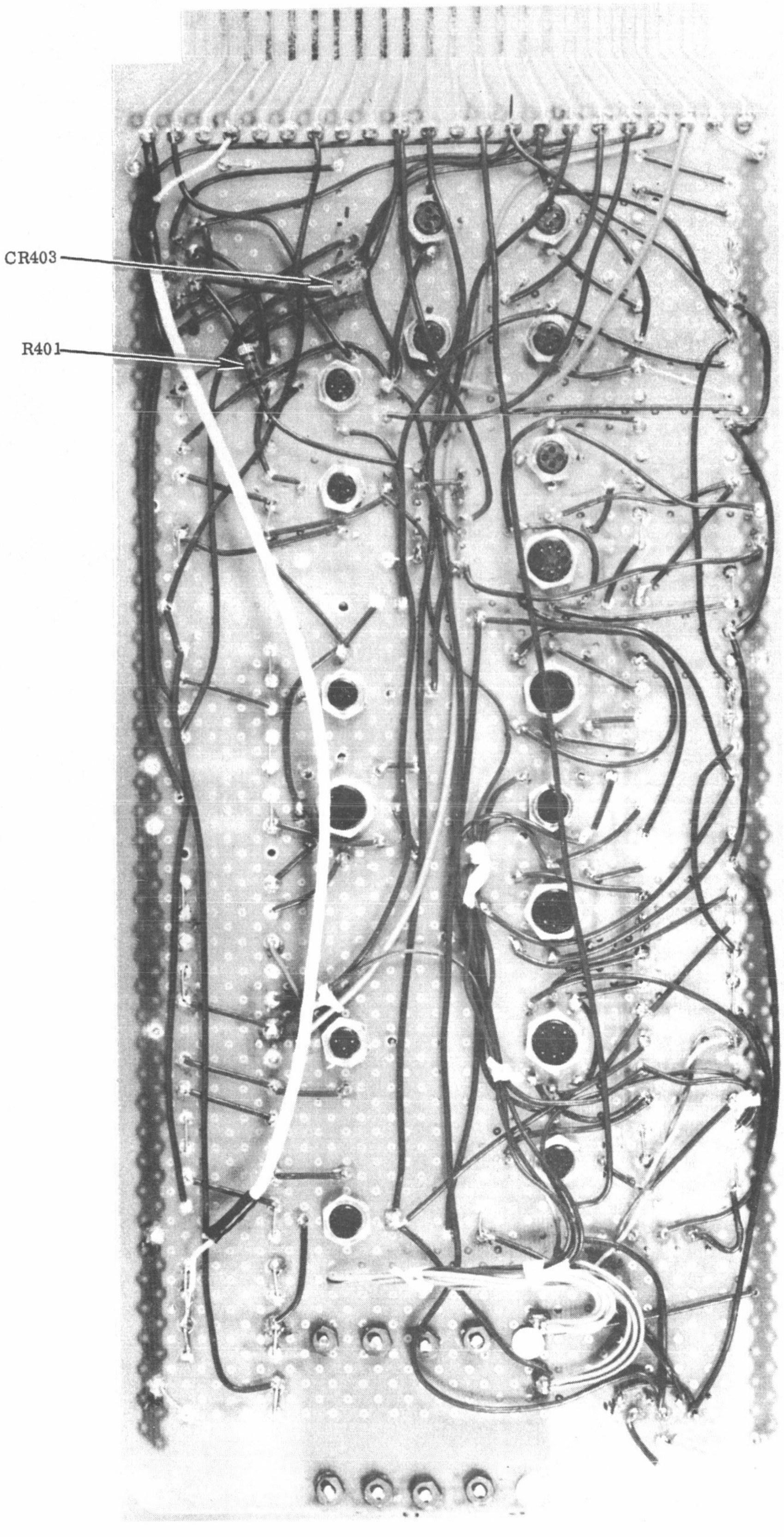
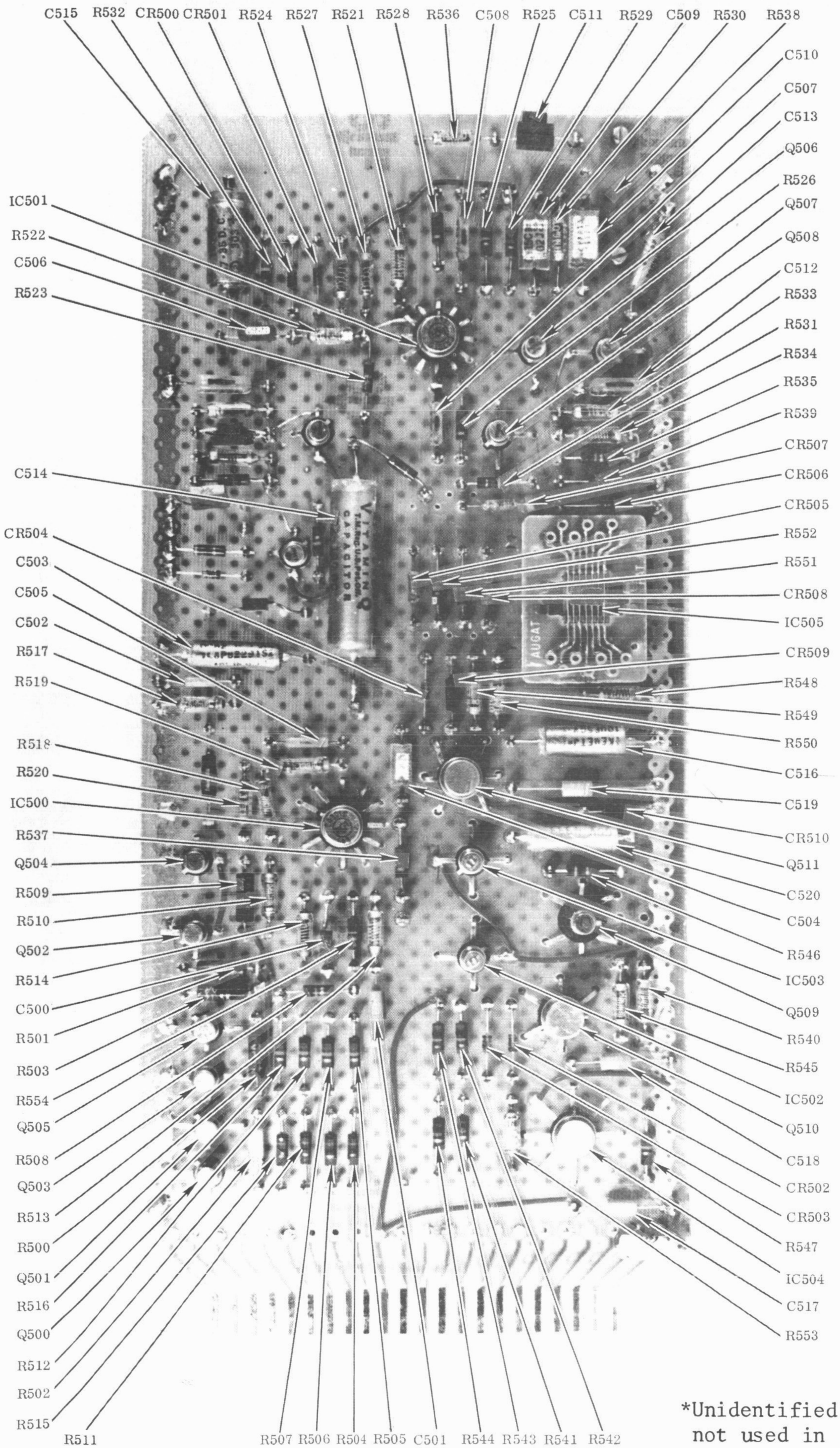


Figure D-8 Bottom View Board 4 Horizontal and Vertical Sweep Circuits



*Unidentified components not used in final system

Figure D-9 Top View Board 5 RF, Video and A/PW Converter

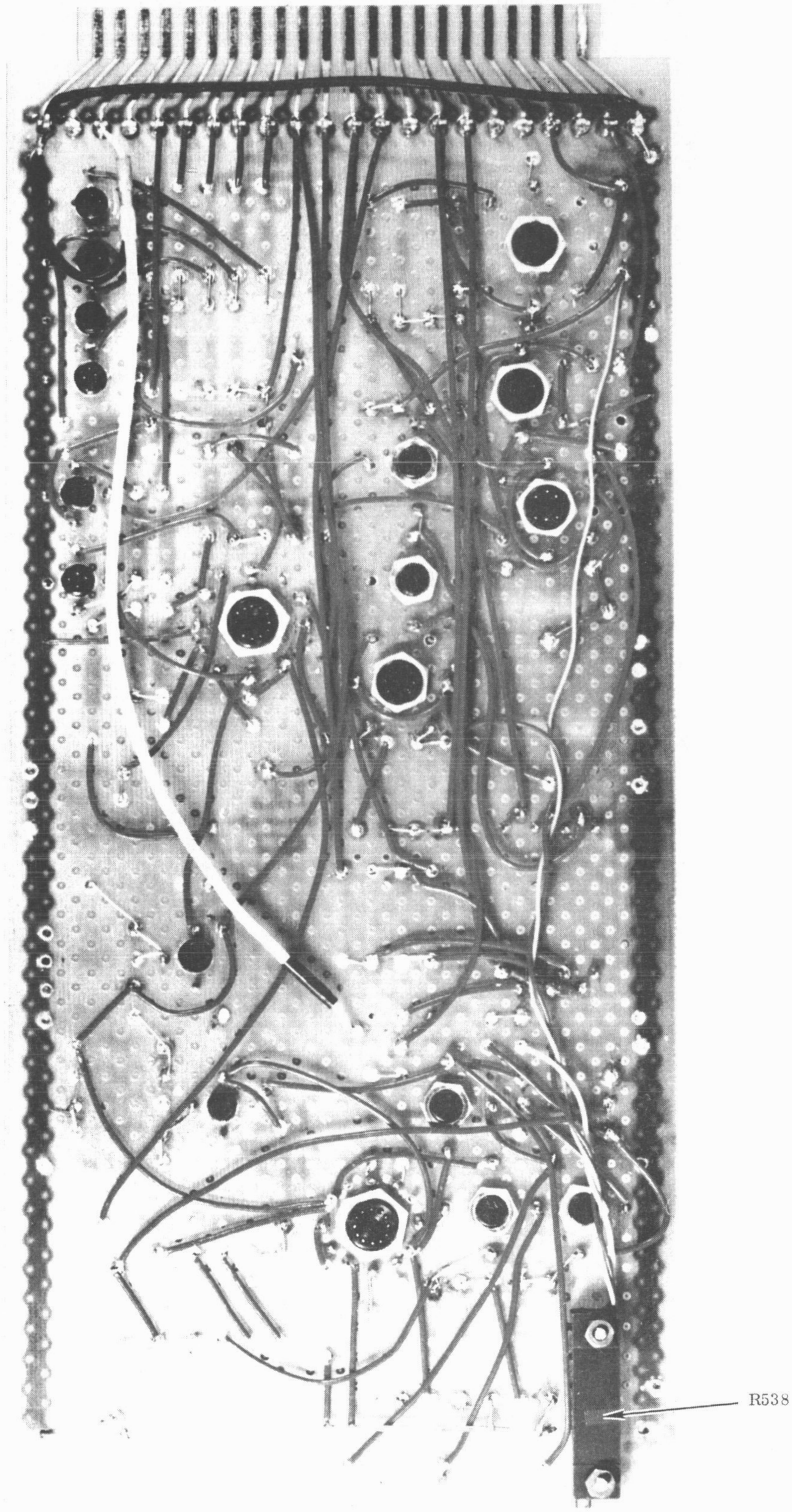


Figure D-10 Bottom View Board 5 RF, Video and A/PW Converter

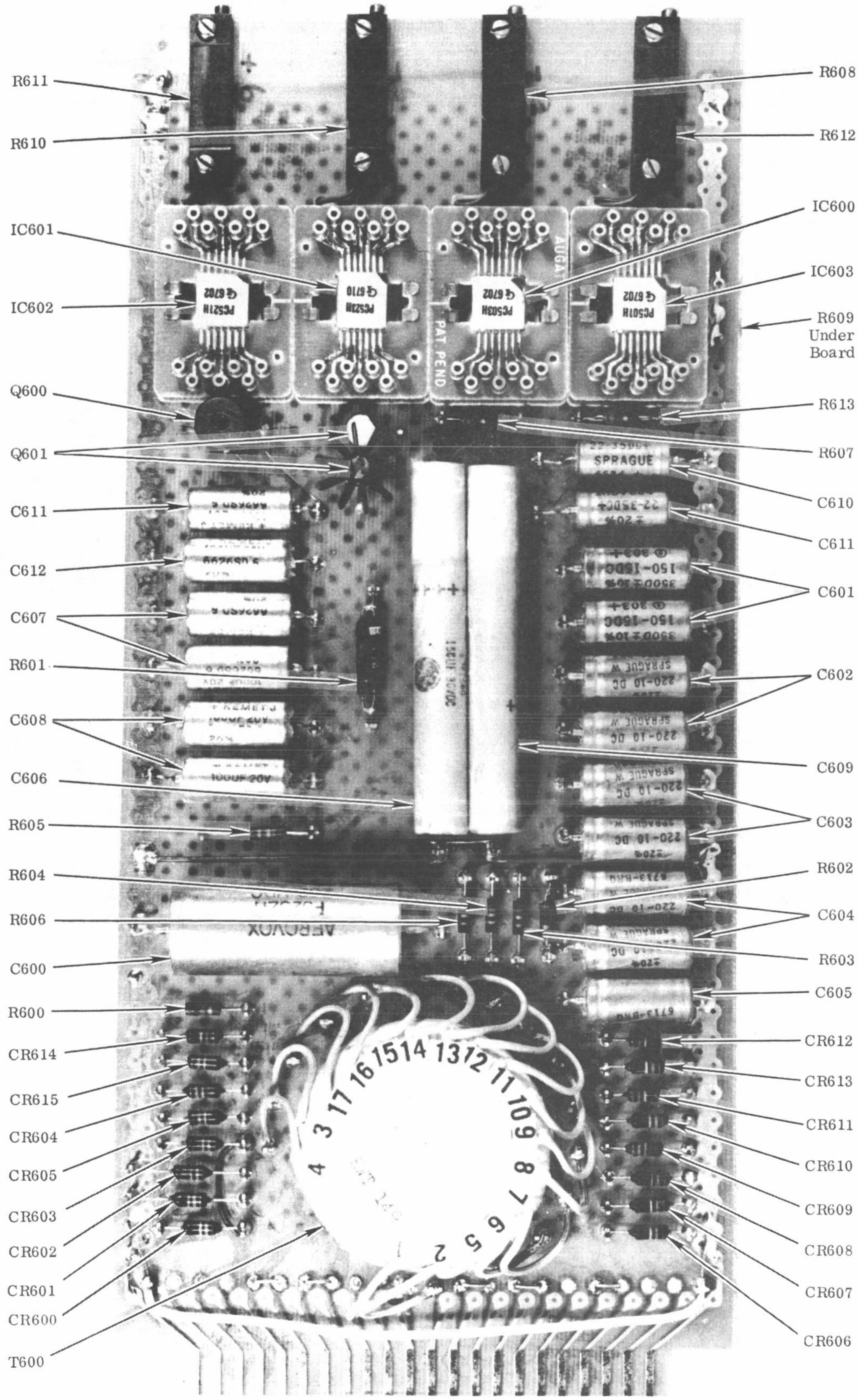


Figure D-11 Top View Board 6 Low Voltage Power Supply

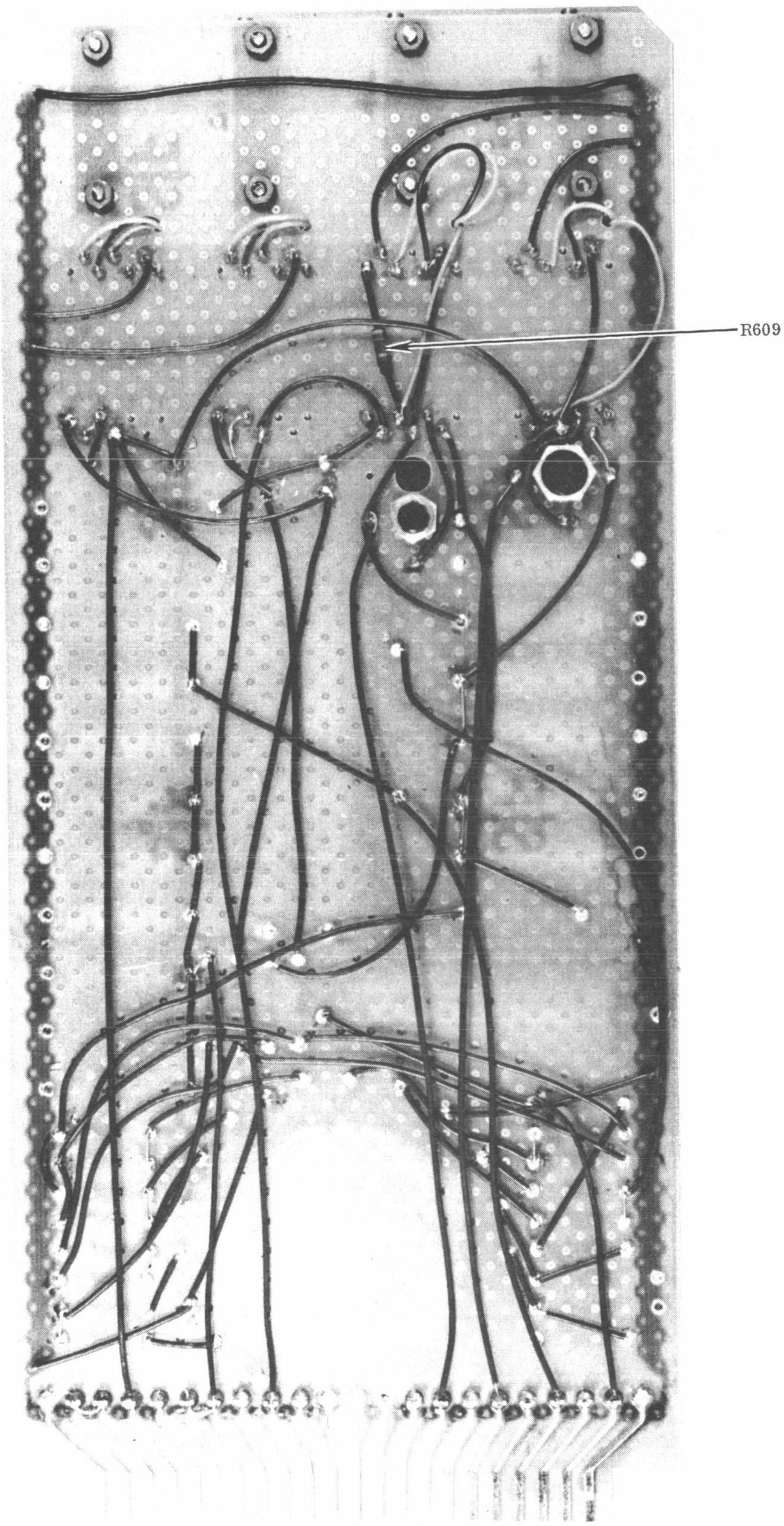


Figure D-12 Bottom View Board 6 Low Voltage Power Supply

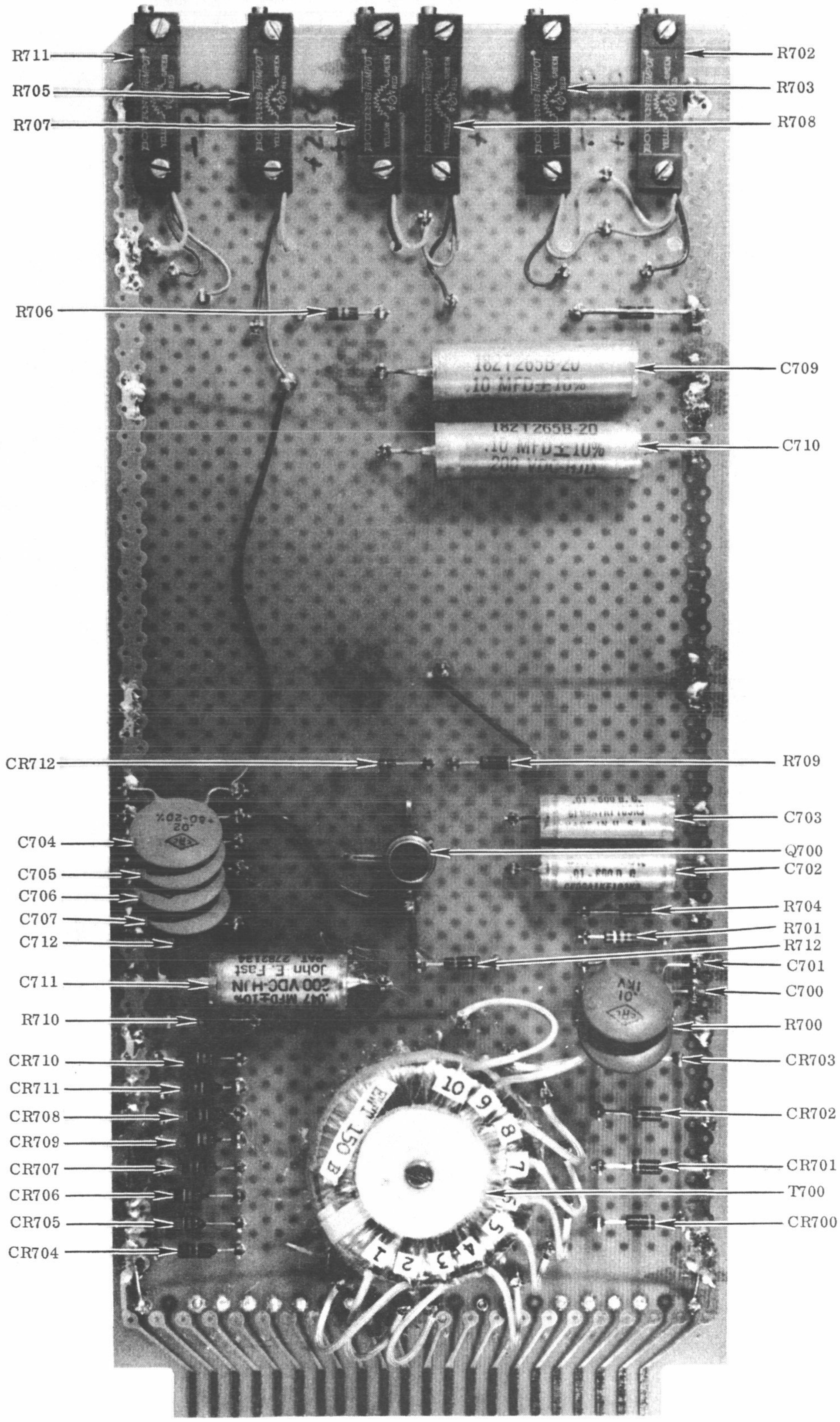
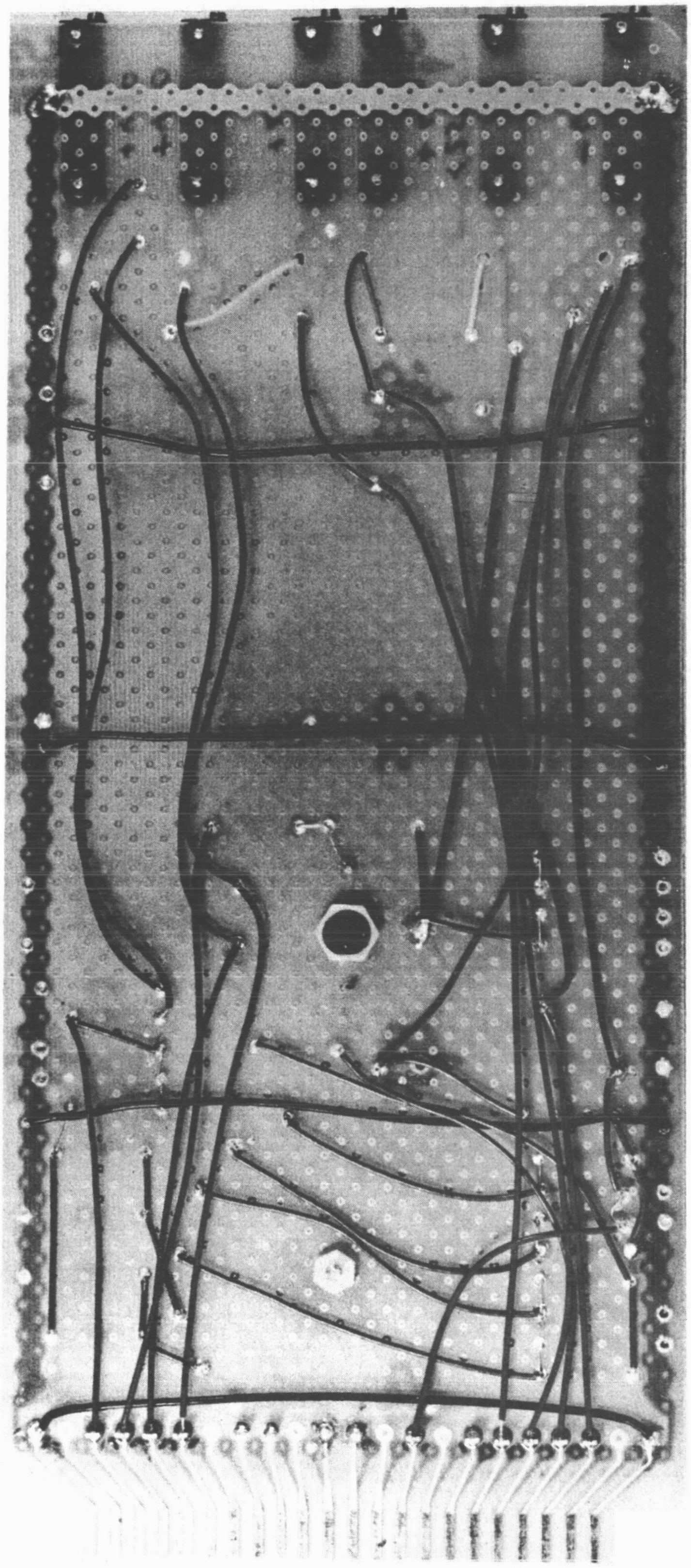


Figure D-13   Top View   Board 7   High Voltage Power Supply



None
Under
Board

Figure D-14 Bottom View Board 7 High Voltage Power Supply

COMPONENT PARTS LIST

RUGGEDIZED IMAGING SYSTEM
PHASE I BREADBOARD

RYAN AERONAUTICAL COMPANY
ELECTRONICS AND SPACE SYSTEMS

BOARD NO. 1

Preamp, G1 Switch and Cathode Chopper

ITEM	REF. DESIG.	IDENT.	PART TYPE	VALUE	RATING	MATERIAL	MFG. OR VENDOR
1	R100	Resistor, Fixed	RC07	5.1K Ω	1/4w ± 5%	Carbon Comp	Allen-Bradley
2	R101	Resistor, Fixed	RC07	6.2K Ω	1/4w ± 5%	Carbon Comp	Allen-Bradley
3	R102	Resistor, Fixed	RC07	51 Ω	1/4w ± 5%	Carbon Comp	Allen-Bradley
4	R103	Resistor, Fixed	RC07	51 Ω	1/4w ± 5%	Carbon Comp	Allen-Bradley
5	R104	Resistor, Fixed	RC07	3.3K Ω	1/4w ± 5%	Carbon Comp	Allen-Bradley
6	R105	Resistor, Fixed	RC07	6.2K Ω	1/4w ± 5%	Carbon Comp	Allen-Bradley
7	R106	Resistor, Fixed	RC07	2.50K Ω	1/4w ± 5%	Carbon Comp	Allen-Bradley
8	R107	Potentiometer	RJ12	100K Ω	1w ± 10%	Carbon	Bourns
9	R108	Resistor, Fixed	RC07	1 meg Ω	1/4w ± 5%	Carbon Comp	Allen-Bradley
10	R109	Resistor, Fixed	RC07	180K Ω	1/4w ± 5%	Carbon Comp	Allen-Bradley
11	R110	Resistor, Fixed	RC07	180K Ω	1/4w ± 5%	Carbon Comp	Allen-Bradley
12	R111	Resistor, Fixed	RNR60C	1.8K Ω	1/8w ± 1%	Metal Film	Mepco
13	R112	Resistor, Fixed	RC07	75K Ω	1/4w ± 5%	Carbon Comp	Allen-Bradley
14	R113	Resistor, Fixed	RC07	47K Ω	1/4w ± 5%	Carbon Comp	Allen-Bradley
15	R114	Resistor, Fixed	RC07	15K Ω	1/4w ± 5%	Carbon Comp	Allen-Bradley
16	R115	Potentiometer	RJ12	500K Ω	1w ± 10%	Carbon	Bourns
17	R116	Resistor, Fixed	RC07	43K Ω	1/4w ± 5%	Carbon Comp	Allen-Bradley
18	R117	Resistor, Fixed	RC07	43K Ω	1/4w ± 5%	Carbon Comp	Allen-Bradley
19	R118	Resistor, Fixed	RC07	39K Ω	1/4w ± 5%	Carbon Comp	Allen-Bradley
20	R119	Resistor, Fixed	MG710	10 meg Ω	1w 1%	Metal Oxide	Caddock
21	R120	Resistor, Fixed	MG710	10 meg Ω	1w 1%	Metal Oxide	Caddock
22	R121	Resistor, Fixed	RC07	68K Ω	1/4w ± 5%	Carbon Comp	Allen-Bradley

COMPONENT PARTS LIST

RUGGEDIZED IMAGING SYSTEM
PHASE I BREADBOARD

RYAN AERONAUTICAL COMPANY
ELECTRONICS AND SPACE SYSTEMS

BOARD NO. 1

ITEM	REF. DESIG.	IDENT.	PART TYPE	VALUE	RATING	MATERIAL	MFG. OR VENDOR
23	R122	Resistor, Fixed	RC07	1K Ω	1/4w ± 5%	Carbon Comp	Allen-Bradley
24	R123	Resistor, Fixed	RC07	3.9K Ω	1/4w ± 5%	Carbon Comp	Allen-Bradley
25	R124	Resistor, Fixed	RC07	10K Ω	1/4w ± 5%	Carbon Comp	Allen-Bradley
26	R125	Resistor, Fixed	RC07	470 Ω	1/4w ± 5%	Carbon Comp	Allen-Bradley
27	R126	Resistor, Fixed	RC07	5.6K Ω	1/4w ± 5%	Carbon Comp	Allen-Bradley
28	R127	Resistor, Fixed	RC07	470 Ω	1/4w ± 5%	Carbon Comp	Allen-Bradley
29	R128	Potentiometer	RJ12	50K Ω	1w ± 10%	Carbon	Bourns
30	R129	Resistor Fixed	RNR60C	1K Ω	1/8w ± 1%	Metal Film	Mepco
31	R130	Resistor, Fixed	RNR60C	4.3K Ω	1/8w ± 1%	Metal Film	Mepco
32	R131	Resistor, Fixed	RNR60C	100K Ω	1/8w ± 1%	Metal Film	Mepco
33	R132	Resistor, Fixed	RNR60C	6.2K Ω	1/8w ± 1%	Metal Film	Mepco
34	R133	Resistor, Fixed	RNR60C	10K Ω	1/8w ± 1%	Metal Film	Mepco
35	R134	Resistor, Fixed	RNR60C	10K Ω	1/8w ± 1%	Metal Film	Mepco
36	R135	Resistor, Fixed	RC07	200 Ω	1/4w ± 5%	Carbon Comp	Allen-Bradley
37	R136	Resistor, Fixed	RC07	1.5K Ω	1/4w ± 5%	Carbon Comp	Allen-Bradley
38	R137	Resistor, Fixed	RC07	1.5K Ω	1/4w ± 5%	Carbon Comp	Allen-Bradley
39	C100	Capacitor	CSR 13	4.7 μfd	10vdc ± 10%	Solid Tantalum	Sprague
40	C101	Capacitor	CSR 13	4.7 μfd	10vdc ± 10%	Solid Tantalum	Sprague
41	C102	Capacitor	CKR 06	200 pfd	200vdc ± 10%	Ceramic	Vitramon
42	C103	Capacitor	CSR 13	4.7 μfd	50vdc ± 10%	Solid Tantalum	Sprague
43	C104	Capacitor	CKR 06	.1 μfd	100vdc ± 10%	Ceramic	Vitramon

COMPONENT PARTS LIST

RUGGEDIZED IMAGING SYSTEM
PHASE I BREADBOARD

RYAN AERONAUTICAL COMPANY
ELECTRONICS AND SPACE SYSTEMS

BOARD NO. 1

ITEM	REF. DESIG.	IDENT.	PART TYPE	VALUE	RATING	MATERIAL	MFG. OR VENDOR
44	C105	Capacitor	CKR 06	.1 μfd	100vdc ± 10%	Ceramic	Vitramon
45	C106	Capacitor	CYFR	.001μfd	500vdc ± 10%	Glass	Corning
46	C107	Capacitor	CSR 13	4.7 μfd	50vdc ± 10%	Soldi Tantalum	Sprague
47	C108	Capacitor	CSR 13	4.7 μfd	50vdc ± 10%	Solid Tantalum	Sprague
48	C109	Capacitor	CSR 13	4.7 μfd	50vdc ± 10%	Solid Tantalum	Sprague
49	C110	Capacitor	CSR 13	4.7 μfd	50vdc ± 10%	Solid Tantalum	Sprague
50	C111	Capacitor	CYFR	39 pfd	500vdc ± 10%	Glass	Corning
51	C112	Capacitor	CYFR	3.3 pfd	500vdc ± 10%	Glass	Corning
52	C113	Capacitor	CKR 06	.01 μfd	200vdc ± 10%	Ceramic	Vitramon
53	C114	Capacitor	CYFR	33 pfd	500vdc ± 10%	Glass	Corning
54	C115	Capacitor	CYFR	33 pfd	500vdc ± 10%	Glass	Corning
55	C116	Capacitor	05 TA 103GN	.01 μfd	200vdc ± 2%	Teflon	Component Research
56	Q100	Transistor	2N2907A			Silicon	
57	Q101	Transistor	2N708			Silicon	
58	Q102	Transistor	2N1893			Silicon	
59	Q103	Transistor	2N1893			Silicon	
60	Q104	Transistor	2N2060			Silicon	
61	Q105	Transistor	2N3930			Silicon	
62	Q106	Transistor	2N2907A			Silicon	
63	Q107	Transistor - Fet	2N3969			Silicon	
64	CR100	Diode	1N916			Silicon	

COMPONENT PARTS LIST

RUGGEDIZED IMAGING SYSTEM
PHASE I BREADBOARD

RYAN AERONAUTICAL COMPANY
ELECTRONICS AND SPACE SYSTEMS

BOARD NO. 1

ITEM	REF. DESIG.	IDENT.	PART TYPE	VALUE	RATING	MATERIAL	MFG. OR VENDOR
65	CR101	Diode	1N916			Silicon	
66	CR102	Diode	1N916			Silicon	
67	CR103	Diode	1N916			Silicon	
68	CR104	Diode	1N916			Silicon	
69	CR105	Diode, Reference	1N827A			Silicon	
70	CR106	Diode	1N649			Silicon	
71	IC 100	Integrated Ckt	μA 709	To-5		Silicon	Fairchild
72	IC 101	Integrated Ckt	CA 3010	To-5		Silicon	RCA
73	L-100	Inductor	93282	82 μ hy	± 5%	Min Toroid	Vanguard

COMPONENT PARTS LIST

RUGGEDIZED IMAGING SYSTEM
PHASE I BREADBOARD

RYAN AERONAUTICAL COMPANY
ELECTRONICS AND SPACE SYSTEMS

BOARD NO. 1A

Shutter Drive

ITEM	REF. DESIG.	IDENT.	PART TYPE	VALUE	RATING	MATERIAL	MFG. OR VENDOR
1	R1	Resistor, Fixed	RC07	6.8K Ω	1/4w ± 5%	Carbon Comp	Allen Bradley
2	R2	Resistor, Fixed	RC07	6.8K Ω	1/4w ± 5%	Carbon Comp	Allen Bradley
3	R3	Resistor, Fixed	RC07	10K Ω	1/4w ± 5%	Carbon Comp	Allen Bradley
4	R4	Resistor, Fixed	RC07	10K Ω	1/4w ± 5%	Carbon Comp	Allen Bradley
5	R5	Resistor, Fixed	RC07	10K Ω	1/4w ± 5%	Carbon Comp	Allen Bradley
6	R6	Resistor, Fixed	RC07	12K Ω	1/4w ± 5%	Carbon Comp	Allen Bradley
7	R7	Resistor, Fixed	RC07	1K Ω	1/4w ± 5%	Carbon Comp	Allen Bradley
8	R8	Resistor, Fixed	RC07	1K Ω	1/4w ± 5%	Carbon Comp	Allen Bradley
9	R9	Resistor, Fixed	RC07	10K Ω	1/4w ± 5%	Carbon Comp	Allen Bradley
10	R10	Resistor, Fixed	RC07	12K Ω	1/4w ± 5%	Carbon Comp	Allen Bradley
11	R11	Resistor, Fixed	RC07	1K Ω	1/4w ± 5%	Carbon Comp	Allen Bradley
12	R12	Resistor, Fixed	RC07	1K Ω	1/4w ± 5%	Carbon Comp	Allen Bradley
13	R13	Resistor, Fixed	RC07	1K Ω	1/4w ± 5%	Carbon Comp	Allen Bradley
14	R14	Resistor, Fixed	RC07	1K Ω	1/4w ± 5%	Carbon Comp	Allen Bradley
15	C-1	Capacitor	29F1089	660 μ fd	50v	Tantalum	G.E
16	C-2	Capacitor	29F1089	660 μ fd	50v	Tantalum	G.E
17	Q-1	Transistor	2N4029			Silicon	
18	Q-2	Transistor	2N4029			Silicon	
19	Q-3	Transistor	2N2907A			Silicon	
20	Q-4	Transistor	2N2907A			Silicon	

COMPONENT PARTS LIST

RUGGEDIZED IMAGING SYSTEM
PHASE I BREADBOARD

RYAN AERONAUTICAL COMPANY
ELECTRONICS AND SPACE SYSTEMS

BOARD NO. 1A

ITEM	REF. DESIG.	IDENT.	PART TYPE	VALUE	RATING	MATERIAL	MFG. OR VENDOR
21	Q-5	Transistor	2N2222 A			Silicon	
22	Q-6	Transistor	2N2222 A			Silicon	
23	CR1	Diode	1N649			Silicon	
24	CR2	Diode	1N649			Silicon	
25	CR3	Diode	1N649			Silicon	
26	CR4	Diode	1N649			Silicon	
27	CR5	Diode	1N649			Silicon	
28	CR6	Diode	1N916			Silicon	
29	CR7	Diode	1N916			Silicon	
30	CR8	Diode	1N916			Silicon	

COMPONENT PARTS LIST

RUGGEDIZED IMAGING SYSTEM
PHASE I BREADBOARD

RYAN AERONAUTICAL COMPANY
ELECTRONICS AND SPACE SYSTEMS

BOARD NO. 1B
Decoupling Ckts.

ITEM	REF. DESIG.	IDENT.	PART TYPE	VALUE	RATING	MATERIAL	MFG. OR VENDOR
	R1	Resistor, Fixed	RC07	20K ± 5%	1/4w	Carbon Comp	Allen Bradley
	R2	Resistor, Fixed	RC07	200K ± 5%	1/4w	Carbon Comp	Allen Bradley
	R3	Resistor, Fixed	RC07	200K ± 5%	1/4w	Carbon Comp	Allen Bradley
	R4	Resistor, Fixed	RC07	20K ± 5%	1/4w	Carbon Comp	Allen Bradley
	C1	Capacitor	118P	.022 μfd	600vdc	Paper-Mylar	Sprague
	C2	Capacitor	118P	.022 μfd	600vdc	Paper-Mylar	Sprague
	C3	Capacitor	118P	.01 μfd	1000vdc	Paper-Mylar	Sprague
	C4	Capacitor	CKR06	.01 μfd	200vdc	Ceramic	Vitramon
	C5	Capacitor	118P	.01 μfd	1000vdc	Paper-Mylar	Sprague
	C6	Capacitor	118P	.01 μfd	1000vdc	Paper-Mylar	Sprague
	CR1	Diode, Zener	1N3016B	6.8v ± 5%	1w		
	F1	Fuse		1a			

COMPONENT PARTS LIST

RUGGEDIZED IMAGING SYSTEM
PHASE I BREADBOARD

RYAN AERONAUTICAL COMPANY
ELECTRONICS AND SPACE SYSTEMS

BOARD NO. 2

Timing And Control

ITEM	REF. DESIG.	IDENT.	PART TYPE	VALUE	RATING	MATERIAL	MFG. OR VENDOR
1	R200	Resistor, Fixed	RC07	20KΩ	1/4w ± 5%	Carbon Comp	Allen Bradley
2	R201	Resistor, Fixed	RC07	5.1KΩ	1/4w ± 5%	Carbon Comp	Allen Bradley
3	R202	Resistor, Fixed	RC07	10KΩ	1/4w ± 5%	Carbon Comp	Allen Bradley
4	R203	Resistor, Fixed	RNR60C	2KΩ	1/8w ± 1%	Metal Film	Mepco
5	R204	Sensistor	TM 1/8	1KΩ	1/8w ± 5%		Texas Inst.
6	R205	Resistor, Fixed	RNR60C	10KΩ	1/8w ± 1%	Metal Film	Mepco
7	R206	Resistor, Fixed	RC07	2KΩ	1/4w ± 5%	Carbon Comp	Allen Bradley
8	R207	Resistor, Fixed	RC07	2KΩ	1/4w ± 5%	Carbon Comp	Allen Bradley
9	R208	Resistor, Fixed	RNR60C	2KΩ	1/8w ± 1%	Metal Film	Mepco
10	R209	Sensistor	TM 1/8	1KΩ	1/8w ± 5%		Texas Inst.
11	R210	Resistor, Fixed	RNR60C	10KΩ	1/8w ± 5%	Metal Film	Mepco
12	R211	Resistor, Fixed	RC07	510Ω	1/4w ± 5%	Carbon Comp	Allen Bradley
13	C200	Capacitor	CYFR	30 pfd	500v ± 10%	Glass	Corning
14	C201	Capacitor	CYFR	30 pfd	500v ± 10%	Glass	Corning
15	C202	Capacitor	CYFR	15 pfd	500v ± 10%	Glass	Corning
16	C203	Capacitor	CYFR	33 pfd	500v ± 10%	Glass	Corning
17	C204	Capacitor	CYFR	18 pfd	500v ± 10%	Glass	Corning
18	C205	Capacitor	CKR06	.01 μfd	200v ± 10%	Ceramic	Vitramon
19	C206	Capacitor	CKR06	.01 μfd	200v ± 10%	Ceramic	Vitramon
20	Q200	Transistor	2N708			Silicon	
21	Q201	Transistor	2N708			Silicon	

COMPONENT PARTS LIST

RUGGEDIZED IMAGING SYSTEM
PHASE I BREADBOARD

RYAN AERONAUTICAL COMPANY
ELECTRONICS AND SPACE SYSTEMS

BOARD NO. 2

ITEM	REF. DESIG.	IDENT.	PART TYPE	VALUE	RATING	MATERIAL	MFG. OR VENDOR
22	CR200	Diode	1N916			Silicon	
23	CR201	Diode	1N916			Silicon	
24	CR202	Diode	1N916			Silicon	
25	CR203	Diode	1N916			Silicon	
26	CR204	Diode	1N916			Silicon	
27	CR205	Diode	1N916			Silicon	
28	CR206	Diode	1N916			Silicon	
29	CR207	Diode	1N916			Silicon	
30	CR208	Diode	1N916			Silicon	
31	IC200	Integrated Ckt	D T μL 951	Monostable Multi Vibrator		Silicon	Fairchild
32	IC201	Integrated Ckt	D T μL 951	Monostable Multi Vibrator		Silicon	Fairchild
33	IC202	Integrated Ckt	D T μ L 944	Dual 4 Input Driver			Fairchild
34	IC203	Integrated Ckt	DTLP μ L9040	Flip-Flop		Silicon	Fairchild
35	IC204	Integrated Ckt	DTLP μ L9040	Flip-Flop		Silicon	Fairchild
36	IC205	Integrated Ckt	DTLP μ L9040	Flip-Flop		Silicon	Fairchild
37	IC206	Integrated Ckt	DTLP μ L9040	Flip-Flop		Silicon	Fairchild
38	IC207	Integrated Ckt	DTLP μ L9040	Flip-Flop		Silicon	Fairchild
39	IC208	Integrated Ckt	DTLP μ L9040	Flip-Flop		Silicon	Fairchild
40	IC209	Integrated Ckt	DTLP μ L9040	Flip-Flop		Silicon	Fairchild
41	IC210	Integrated Ckt	DTLP μ L9040	Flip-Flop		Silicon	Fairchild
42	IC211	Integrated Ckt	DTLP μ L9040	Flip-Flop		Silicon	Fairchild

COMPONENT PARTS LIST

RUGGEDIZED IMAGING SYSTEM
PHASE I BREADBOARD

RYAN AERONAUTICAL COMPANY
ELECTRONICS AND SPACE SYSTEMS

BOARD NO. 2

ITEM	REF. DESIG.	IDENT.	PART TYPE	VALUE	RATING	MATERIAL	MFG. OR VENDOR
43	IC212	Integrated Ckt	DTLP μ L9040	Flip-Flop		Silicon	Fairchild
44	IC213	Integrated Ckt	DTLP μ L9040	Flip-Flop		Silicon	Fairchild
45	IC214	Integrated Ckt	DTLP μ L9040	Flip-Flop		Silicon	Fairchild
46	IC215	Integrated Ckt	DTLP μ L9040	Flip-Flop		Silicon	Fairchild
47	IC216	Integrated Ckt	DTLP μ L9040	Flip-Flop		Silicon	Fairchild
48	IC217	Integrated Ckt	DTLP μ L9040	Flip-Flop		Silicon	Fairchild
49	IC218	Integrated Ckt	DTLP μ L9040	Flip-Flop		Silicon	Fairchild
50	IC219	Integrated Ckt	DTLP μ L9040	Flip-Flop		Sicicon	Fairchild
51	IC220	Integrated Ckt	DTLP μ L9041	Dual 3 In	put Gate	Silicon	Fairchild
52	IC221	Integrated Ckt	DTLP μ L9041	Dual 3 Inp	ut Gate	Silicon	Fairchild
53	IC222	Integrated Ckt	DTLP μ L9041	Dual 3 Inp	ut Gate	Silicon	Fairchild
54	IC223	Integrated Ckt	DTLP μ L9041	Dual 3 Inp	ut Gate	Silicon	Fairchild
55	IC224	Integrated Ckt	DTLP μ L9041	Dual 3 Inp	ut Gate	Silicon	Fairchild
56	IC225	Integrated Ckt	DTLP μ L9042	Dual 3 Inp	ut Gate	Silicon	Fairchild
57	IC226	Integrated Ckt	DTLP μ L9042	Dual 3 Inp	ut Gate	Silicon	Fairchild
58	IC227	Integrated Ckt	DTLP μ L9041	Dual 3 Inp	ut Gate	Silicon	Fairchild
59	IC228	Integrated Ckt	DTLP μ L9041	Dual 3 Inp	ut Gate	Silicon	Fairchild
60	IC229	Integrated Ckt	DTLP μ L9041	Dual 3 Inp	ut Gate	Silicon	Fairchild
61	IC230	Integrated Ckt	DTLP μ L9042	Dual 3 Input	Gate	Silicon	Fairchild
62	IC231	Integrated Ckt	DTLP μ L9042	Dual 3 Input	Gate	Silicon	Fairchild
63	IC 232	Integrated Ckt	DTLP μ L9042	Dual 3 Input	Gate	Silicon	Fairchild
64	IC233	Integrated Ckt	DTLP μ L9042	Dual 3 Input	Gate	Silicon	Fairchild

COMPONENT PARTS LIST

RUGGEDIZED IMAGING SYSTEM
PHASE I BREADBOARD

RYAN AERONAUTICAL COMPANY
ELECTRONICS AND SPACE SYSTEMS

BOARD NO. 2

ITEM	REF. DESIG.	IDENT.	PART TYPE	VALUE	RATING	MATERIAL	MFG. OR VENDOR
65	IC234	Integrated Ckt	DT μ L 933	Dual 4 Input	Expander	Silicon	Fairchild
66	IC235	Integrated Ckt	DTLP μL 9041	Dual 3 Input	Gate	Silicon	Fairchild

COMPONENT PARTS LIST

RUGGEDIZED IMAGING SYSTEM
PHASE I BREADBOARD

RYAN AERONAUTICAL COMPANY
ELECTRONICS AND SPACE SYSTEMS

BOARD NO. 3

TIMING AND CONTROL

ITEM	REF. DESIG.	IDENT.	PART TYPE	VALUE	RATING	MATERIAL	MFG. OR VENDOR
1.	R300	Resistor, Fixed	RC07	5.1KΩ	1/4w ±5%	Carbon Comp.	Allen Bradley
2.	R301	Resistor, Fixed	RC07	5.1KΩ	1/4w ±5%	Carbon Comp.	Allen Bradley
3.	R302	Resistor, Fixed	RC07	2KΩ	1/4w ±5%	Carbon Comp.	Allen Bradley
4.	R303	Resistor, Fixed	RC07	15KΩ	1/4w ±5%	Carbon Comp.	Allen Bradley
5.	R304	Resistor, Fixed	RC07	15KΩ	1/4w ±5%	Carbon Comp.	Allen Bradley
6.	R305	Resistor, Fixed	RC07	10KΩ	1/4w ±5%	Carbon Comp.	Allen Bradley
7.	C300	Capacitor	CKR06	.01 μ fd	200VDC ±10%	Ceramic	Vitramon
8.	C301	Capacitor	CKR06	.01 μ fd	200VDC ±10%	Ceramic	Vitramon
9.	C302	Capacitor	CKR06	.1 μ fd	100VDC ±10%	Ceramic	Vitramon
10.	Q300	Transistor	2N709			Silicon	
11.	CR300	Diode	1N916			Silicon	
12.	CR301	Diode	1N916			Silicon	
13.	CR302	Diode	1N916			Silicon	
14.	CR303	Diode	1N916			Silicon	
15.	CR304	Diode	1N916			Silicon	
16.	IC300	Integrated Ckt.	DTLP μ L 9040	Flip-Flop		Silicon	Fairchild
17.	IC301	Integrated Ckt.	DTLP μ L 9040	Flip-Flop		Silicon	Fairchild
18.	IC302	Integrated Ckt.	DTLP μ L 9040	Flip-Flop		Silicon	Fairchild
19.	IC303	Integrated Ckt.	DTLP μ L 9040	Flip-Flop		Silicon	Fairchild
20.	IC304	Integrated Ckt.	DTLP μ L 9040	Flip-Flop		Silicon	Fairchild

COMPONENT PARTS LIST

RUGGEDIZED IMAGING SYSTEM
PHASE I BREADBOARD

RYAN AERONAUTICAL COMPANY
ELECTRONICS AND SPACE SYSTEMS

BOARD NO. 3

ITEM	REF. DESIG.	IDENT.	PART TYPE	VALUE	RATING	MATERIAL	MFG. OR VENDOR
21.	IC305	Integrated Ckt.	DTLP μL 9040	Flip-Flop		Silicon	Fairchild
22.	IC306	Integrated Ckt.	DTLP μL 9040	Flip-Flop		Silicon	Fairchild
23.	IC307	Integrated Ckt.	DTLP μL 9040	Flip-Flop		Silicon	Fairchild
24.	IC308	Integrated Ckt.	DTLP μL 9040	Flip-Flop		Silicon	Fairchild
25.	IC309	Integrated Ckt.	DTLP μL 9040	Flip-Flop		Silicon	Fairchild
26.	IC310	Integrated Ckt.	DTLP μL 9040	Flip-Flop		Silicon	Fairchild
27.	IC311	Integrated Ckt.	DTLP μL 9040	Flip-Flop		Silicon	Fairchild
28.	IC312	Integrated Ckt.	DTLP μL 9040	Flip-Flop		Silicon	Fairchild
29.	IC313	Integrated Ckt.	DTLP μL 9040	Flip-Flop		Silicon	Fairchild
30.	IC314	Integrated Ckt.	DTLP μL 9040	Flip-Flop		Silicon	Fairchild
31.	IC315	Integrated Ckt.	DTLP μL 9040	Flip-Flop		Silicon	Fairchild
32.	IC316	Integrated Ckt.	DTLP μL 9040	Flip-Flop		Silicon	Fairchild
33.	IC317	Integrated Ckt.	DTLP μL 9040	Flip-Flop		Silicon	Fairchild
34.	IC318	Integrated Ckt.	DTLP μL 9040	Flip-Flop		Silicon	Fairchild
35.	IC319	Integrated Ckt.	DTLP μL 9040	Flip-Flop		Silicon	Fairchild
36.	IC320	Integrated Ckt.	DTLP μL 9040	Flip-Flop		Silicon	Fairchild
37.	IC321	Integrated Ckt.	DTLP μL 9040	Flip-Flop		Silicon	Fairchild
38.	IC322	Integrated Ckt.	DTLP μL 9040	Flip-Flop		Silicon	Fairchild
39.	IC323	Integrated Ckt.	DTLP μL 9040	Flip-Flop		Silicon	Fairchild
40.	IC324	Integrated Ckt.	DTLP μL 9040	Flip-Flop		Silicon	Fairchild

COMPONENT PARTS LIST

RUGGEDIZED IMAGING SYSTEM
PHASE I BREADBOARD

RYAN AERONAUTICAL COMPANY
ELECTRONICS AND SPACE SYSTEMS

BOARD NO. 3

ITEM	REF. DESIG.	IDENT.	PART TYPE	VALUE	RATING	MATERIAL	MFG. OR VENDOR
41.	IC325	Integrated Ckt.	DTLP μ L 9040	Flip-Flop		Silicon	Fairchild
42.	IC326	Integrated Ckt.	DTLP μ L 9040	Flip-Flop		Silicon	Fairchild
43.	IC327	Integrated Ckt.	DTLP μ L 9040	Flip-Flop		Silicon	Fairchild
44.	IC328	Integrated Ckt.	DTLP μ L 9040	Flip-Flop		Silicon	Fairchild
45.	IC329	Integrated Ckt.	DTLP μ L 9040	Flip-Flop		Silicon	Fairchild
46.	IC330	Integrated Ckt.	DTLP μ L 9041	Dual 3 Input Gate		Silicon	Fairchild
47.	IC331	Integrated Ckt.	DTLP μ L 9041	Dual 3 Input Gate		Silicon	Fairchild
48.	IC332	Integrated Ckt.	DTLP μ L 9041	Dual 3 Input Gate		Silicon	Fairchild
49.	IC333	Integrated Ckt.	DTLP μ L 9041	Dual 3 Input Gate		Silicon	Fairchild
50.	IC334	Integrated Ckt.	DTLP μ L 9041	Dual 3 Input Gate		Silicon	Fairchild
51.	IC335	Integrated Ckt.	DTLP μ L 9041	Dual 3 Input Gate		Silicon	Fairchild
52.	IC336	Integrated Ckt.	DTLP μ L 9041	Dual 3 Input Gate		Silicon	Fairchild
53.	IC337	Integrated Ckt.	DTLP μ L 9041	Dual 3 Input Gate		Silicon	Fairchild
54.	IC338	Integrated Ckt.	DTLP μ L 9041	Dual 3 Input Gate		Silicon	Fairchild
55.	IC339	Integrated Ckt.	DTLP μ L 9041	Dual 3 Input Gate		Silicon	Fairchild
56.	IC340	Integrated Ckt.	DTLP μ L 9041	Dual 3 Input Gate		Silicon	Fairchild
57.	IC341	Integrated Ckt.	DTLP μ L 9041	Dual 3 Input Gate		Silicon	Fairchild
58.	IC342	Integrated Ckt.	DTLP μ L 9041	Dual 3 Input Gate		Silicon	Fairchild
59.	IC343	Integrated Ckt.	DTLP μ L 9041	Dual 3 Input Gate		Silicon	Fairchild
60.	IC344	Integrated Ckt.	DTLP μ L 9041	Dual 3 Input Gate		Silicon	Fairchild

COMPONENT PARTS LIST

RUGGEDIZED IMAGING SYSTEM
PHASE I BREADBOARD

RYAN AERONAUTICAL COMPANY
ELECTRONICS AND SPACE SYSTEMS

BOARD NO. 3

ITEM	REF. DESIG.	IDENT.	PART TYPE	VALUE	RATING	MATERIAL	MFG. OR VENDOR
61.	IC345	Integrated Ckt.	DTLP μL 9042	Dual 3 Input	Gate	Silicon	Fairchild
62.	IC346	Integrated Ckt.	DTLP μL 9042	Dual 3 Input	Gate	Silicon	Fairchild
63.	IC347	Integrated Ckt.	DTLP μL 9042	Dual 3 Input	Gate	Silicon	Fairchild
64.	IC348	Integrated Ckt.	DTLP μL 9042	Dual 3 Input	Gate	Silicon	Fairchild
65.	IC349	Integrated Ckt.	DT μL 933	Dual 4 Input	Expander	Silicon	Fairchild
66.	IC350	Integrated Ckt.	DT μL 933	Dual 4 Input	Expander	Silicon	Fairchild
67.	IC351	Integrated Ckt.	DT μL 933	Dual 4 Input	Expander	Silicon	Fairchild

COMPONENT PARTS LIST

RUGGEDIZED IMAGING SYSTEM
PHASE I BREADBOARD

RYAN AERONAUTICAL COMPANY
ELECTRONICS AND SPACE SYSTEMS

BOARD NO. 4

Sweep Circuits

ITEM	REF. DESIG.	IDENT.	PART TYPE	VALUE	RATING	MATERIAL	MFG. OR VENDOR
1	R400	Resistor, Fixed	RC07	15K Ω	1/4w ± 5%	Carbon Comp	Allen Bradley
2	R401	Resistor, Fixed	RC07	15K Ω	1/4w ± 5%	Carbon Comp	Allen Bradley
3	R402	Potentiometer	RTR12	10K Ω	1 w ± 10%	Wirewound	Bourns
4	R403	Resistor, Fixed	RC07	1 meg Ω	1/4w ± 5%	Carbon Comp	Allen Bradley
5	R404	Resistor, Fixed	RNR60C	17.8K Ω	1/8w ± 1%	Metal Film	Mepco
6	R405	Resistor, Fixed	RC07	1 meg Ω	1/4w ± 5%	Carbon Comp	Allen Bradley
7	R406	Resistor, Fixed	RNR60C	110K Ω	1/8w ± 1%	Metal Film	Mepco
8	R407	Resistor, Fixed	RNR60C	178K Ω	1/8w ± 1%	Metal Film	Mepco
9	R408	Resistor, Fixed	RNR60C	196K Ω	1/8w ± 1%	Metal Film	Mepco
10	R409	Potentiometer	RTR12	10K Ω	1w ± 10%	Wirewound	Bourns
11	R410	Resistor, Fixed	RC07	100Ω	1/4w ± 5%	Carbon Comp	Allen Bradley
12	R411	Resistor, Fixed	RC07	100Ω	1/4w ± 5%	Carbon Comp	Allen Bradley
13	R412	Resistor, Fixed	RC07	1.5K Ω	1/4w ± 5%	Carbon Comp	Allen Bradley
14	R413	Resistor, Fixed	RC07	1 meg Ω	1/4w ± 5%	Carbon Comp	Allen Bradley
15	R414	Resistor, Fixed	RNR60C	100Ω	1/8w ± 1%	Metal Film	Mepco
16	R415	Resistor, Fixed	RWR70G	15Ω	1 w ± 1%	Wirewound	Dale
17	R416	Resistor, Fixed	RC07	2.4K Ω	1/4w ± 5%	Carbon Comp	Allen Bradley
18	R417	Resistor, Fixed	RC07	100Ω	1/4w ± 5%	Carbon Comp	Allen Bradley
19	R418	Resistor, Fixed	RWR70G	7.5Ω	1 w ± 1%	Carbon Comp	Allen Bradley
20	R419	Resistor, Fixed	RWR70G	7.5Ω	1 w ± 1%	Carbon Comp	Allen Bradley

COMPONENT PARTS LIST

RUGGEDIZED IMAGING SYSTEM
PHASE I BREADBOARD

RYAN AERONAUTICAL COMPANY
ELECTRONICS AND SPACE SYSTEMS

BOARD NO. 4

Sweep Circuits

ITEM	REF. DESIG.	IDENT.	PART TYPE	VALUE	RATING	MATERIAL	MFG. OR VENDOR
21	R420	Resistor, Fixed	RBR55	7.5Ω	.2w ± 1%	Wirewound	Kelvin
22	R421	Resistor, Fixed	RNR60C	11KΩ	1/8w ± 1%	Metal Film	Mepco
23	R422	Potentiometer	RTR12	20KΩ	1w ± 10%	Wirewound	Bourns
24	R423	Resistor, Fixed	RC07	100KΩ	1/4w ± 5%	Carbon Comp	Allen Bradley
25	R424	Resistor, Fixed	RNR60C	68.1KΩ	1/8w ± 1%	Metal Film	Mepco
26	R425	Potentiometer	RTR12	20KΩ	1w ± 10%	Wirewound	Bourns
27	R426	Resistor, Fixed	RC07	133KΩ	1/4w ± 5%	Carbon Comp	Allen Bradley
28	R427	Resistor, Fixed	RC07	62KΩ	1/4w ± 5%	Carbon Comp	Allen Bradley
29	R428	Resistor, Fixed	RC07	133KΩ	1/4w ± 5%	Carbon Comp	Allen Bradley
30	R429	Resistor, Fixed	RC07	100Ω	1/4w ± 5%	Carbon Comp	Allen Bradley
31	R430	Resistor, Fixed	RC07	15KΩ	1/4w ± 5%	Carbon Comp	Allen Bradley
32	R431	Resistor, Fixed	RC07	1 megΩ	1/4w ± 5%	Carbon Comp	Allen Bradley
33	R432	Resistor Fixed	RC07	1 megΩ	1/4w ± 5%	Carbon Comp	Allen Bradley
34	R433	Potentiometer	RTR12	20KΩ	1w ± 10%	Wirewound	Bourns
35	R434	Resistor, Fixed	RC07	27KΩ	1/4w ± 5%	Carbon Comp	Allen Bradley
36	R435	Resistor, Fixed	RC07	30KΩ	1/4w ± 5%	Carbon Comp	Allen Bradley
37	R436	Resistor, Fixed	RC07	27KΩ	1/4w ± 5%	Carbon Comp	Allen Bradley
38	R437	Resistor, Fixed	RC07	120KΩ	1/4w ± 5%	Carbon Comp	Allen Bradley
39	R438	Resistor, Fixed	RC07	120KΩ	1/4w ± 5%	Carbon Comp	Allen Bradley
40	R439	Deleted					

COMPONENT PARTS LIST

RUGGEDIZED IMAGING SYSTEM
PHASE I BREADBOARD

RYAN AERONAUTICAL COMPANY
ELECTRONICS AND SPACE SYSTEMS

BOARD NO. 4
Sweep Circuits

ITEM	REF. DESIG.	IDENT.	PART TYPE	VALUE	RATING	MATERIAL	MFG. OR VENDOR
41	R440	Resistor Fixed	RC07	10 megΩ	1/4w ± 5%	Carbon Comp	Allen Bradley
42	R441	Resistor Fixed	RC07	10KΩ	1/4w ± 5%	Carbo n Comp	Allen Bradley
43	R442	Resistor Fixed	RC07	100Ω	1/4w ± 5%	Carbon Comp	Allen Bradley
44	R443	Resistor Fixed	RC07	2.4KΩ	1/4w ± 5%	Carbon Comp	Allen Bradley
45	R444	Resistor Fixed	RC07	20KΩ	1/4w ± 5%	Carbon Comp	Allen Bradley
46	R445	Resistor Fixed	RC07	5KΩ	1/4w ± 5%	Carbon Comp	Allen Bradley
47	R446	Resistor Fixed	RC07	47KΩ	1/4w ± 5%	Carbon Comp	Allen Bradley
48	R447	Resistor Fixed	RC07	1 megΩ	1/4w ± 5%	Carbon Comp	Allen Bradley
49	R448	Resistor Fixed	RC07	5KΩ	1/4w ± 5%	Carbon Comp	Allen Bradley
50	R449	Resistor Fixed	RWR70G	15Ω	1 w ± 1%	Carbon Comp	Dale
51	R450	Resistor Fixed	RWR70G	7.5Ω	1 w ± 1%	Carbon Comp	Dale
52	R451	Resistor Fixed	RWF70G	7.5Ω	1 w ± 1%	Carbon Comp	Dale
53	R452	Resistor Fixed	RBR55C	7.5Ω	.2w ± 1%	Wirewound	Kelvin
54	R453	Resistor Fixed	RC07	33KΩ	1/4w ± 5%	Carbon Comp	Allen Bradley
55	R454	Resistor Fixed	MG710	10 meg Ω	1%	Wirewound	Caddock
56	C400	Capacitor	CSR 13	39 μfd	10vdc ± 10%	Solid Tantalum	Sprague
57	C401	Capacitor	CSR 13	39 μfd	10vdc ± 10%	Solid Tantalum	Sprague
58	C402	Capacitor	CSR 13	4.7 μfd	50vdc ± 10%	Solid Tantalum	Sprague
59	C403	Capacitor	CKR06	4200 pfd	200vdc ± 10%	Ceramic	Vitramon
60	C404	Capacitor	CYFR	200 pfd	300 vdc ± 10%	Glass	Corning

COMPONENT PARTS LIST

RUGGEDIZED IMAGING SYSTEM
PHASE I BREADBOARD

RYAN AERONAUTICAL COMPANY
ELECTRONICS AND SPACE SYSTEMS

BOARD NO. 4

Sweep Circuits

ITEM	REF. DESIG.	IDENT.	PART TYPE	VALUE	RATING	MATERIAL	MFG. OR VENDOR
61	C405	Capacitor	PV154G	.15 μ fd	30vdc ± 2%	Polycarbonate	Component Research
62	C406	Capacitor	CSR 13	4.7 μ fd	50vdc ± 10%	Solid Tantalum	Sprague
63	C407	Capacitor	CSR 13	39 μ fd	10vdc ± 10%	Solid Tantalum	Sprague
64	C408	Capacitor	CKR 06	.1 μ fd	100vdc ± 10%	Ceramic	Vitramon
65	C409	Capacitor	CSR 13	4.7 μ fd	10vdc ± 10%	Solid Tantalum	Sprague
66	C410	Capacitor	CSR 13	4.7 μ fd	50vdc ± 10%	Solid Tantalum	Sprague
67	C411	Capacitor	PV205G	2 μ fd	± 2% 30vdc	Polycarbonate	Component Research
68	C412	Capacitor	CKR 06	.1 μ fd	± 10% 100vdc	Ceramic	Vitramon
69	C413	Capacitor	CKR 06	.01 μ fd	± 10% 200vdc	Ceramic	Vitramon
70	C414	Capacitor	CSR 13	15 μ fd	± 10% 20vdc	Solid Tantalum	Sprague
71	C415	Capacitor	CKR 06	.1 μ fd	± 10% 100vdc	Ceramic	Vitramon
72	C416	Capacitor	CKR 06	.0027 μ fd	± 10% 200 vdc	Ceramic	Vitramon
73	C417	Capacitor	CKR 06	.01 μ fd	± 10% 200 vdc	Ceramic	Vitramon
74	C418	Capacitor	CKR 06	.0027 μ fd	± 10% 200 vdc	Ceramic	Vitramon
75	Q400	Transistor Fet	2N4392				
76	Q401	Transistor Fet	2N 4392				
77	Q402	Transistor Fet	2N4392				
78	Q403	Transistor	2N2219A				
79	Q404	Transistor	2N2905A				
80	Q405	Transistor Dual	2N4024				

COMPONENT PARTS LIST

RUGGEDIZED IMAGING SYSTEM
PHASE I BREADBOARD

RYAN AERONAUTICAL COMPANY
ELECTRONICS AND SPACE SYSTEMS

BOARD NO. 4
Sweep Circuits

ITEM	REF. DESIG.	IDENT.	PART TYPE	VALUE	RATING	MATERIAL	MFG. OR VENDOR
81	Q406	Transistor Dual	2N2060				
82	Q407	Transistor Fet	2N4392				
83	Q408	Transistor Fet	2N3382				
84	Q409	Transistor Dual	2N4024				
85	Q410	Transistor Dual Fet	2N3954				
86	Q411	Transistor Fet	2N4392				
87	Q412	Transistor	2N2907A				
88	Q413	Transistor Fet	2N3969				
89	Q414	Transistor	2N2219A				
90	Q415	Transistor	2N2905A				
91	CR400	Diode	1N916				
92	CR401	Diode	1N916				
93	CR402	Diode	1N916				
94	CR403	Diode	1N916				
95	CR404	Diode	1N916				
96	CR405	Diode	1N916				
97	CR406	Diode	1N916				
98	CR407	Diode	1N916				
99	CR408	Diode	1N916				
100	CR409	Diode	1N916				

COMPONENT PARTS LIST

RUGGEDIZED IMAGING SYSTEM
PHASE I BREADBOARD

RYAN AERONAUTICAL COMPANY
ELECTRONICS AND SPACE SYSTEMS

BOARD NO. 4
Sweep Circuits

ITEM	REF. DESIG.	IDENT.	PART TYPE	VALUE	RATING	MATERIAL	MFG. OR VENDOR
101	CR410	Diode	1N916				
102	CR411	Diode	1N916				
103	CR412	DELETED					
104	CR413	Diode	1N916				
105	CR414	Diode	1N916				
106	CR415	Diode	1N916				
107	CR416	Diode	1N916				
108	CR417	Diode	1N916				
109	CR418	Diode	1N916				
110	CR419	Diode	1N916				
111	CR420	Diode	1N916				
112	CR421	Diode	1N916				
113	IC400	Integrated Ckt	D111F	Flat Pack			Siliconix
114	IC401	Integrated Ckt	μA709	To-5			Fairchild
115	IC402	Integrated Ckt	D111F	Flat Pack			Siliconix
116	IC403	Integrated Ckt	DTLPμL9041	Dual In-Line			Fairchild

RYAN AERONAUTICAL COMPANY
ELECTRONICS AND SPACE SYSTEMS

COMPONENT PARTS LIST

RUGGEDIZED IMAGING SYSTEM
PHASE I BREADBOARD

BOARD NO. 5

RF, Video and A/PW Converter

ITEM	REF. DESIG.	IDENT.	PART TYPE	VALUE	RATING	MATERIAL	MFG. OR VENDOR
1	R500	Resistor Fixed	RNR60C	1.05KΩ	1/8w ± 1%	Metal Film	Mepco
2	R501	Resistor Fixed	RNR60C	28.0KΩ	1/8w ± 1%	Metal Film	Mepco
3	R502	Resistor Fixed	RNR60C	2.0KΩ	1/8w ± 1%	Metal Film	Mepco
4	R503	Resistor Fixed	RNR60C	21.5KΩ	1/8w ± 1%	Metal Film	Mepco
5	R504	Resistor Fixed	RC07	5.1KΩ	1/4w ± 5%	Carbon Comp	Allen Bradley
6	R505	Resistor Fixed	RC07	51KΩ	1/4w ± 5%	Carbon Comp	Allen Bradley
7	R506	Resistor Fixed	RC07	5.1KΩ	1/4w ± 5%	Carbon Comp	Allen Bradley
8	R507	Resistor Fixed	RC07	51KΩ	1/4w ± 5%	Carbon Comp	Allen Bradley
9	R508	Resistor Fixed	RC07	20KΩ	1/4w ± 5%	Carbon Comp	Allen Bradley
10	R509	Resistor Fixed	RNR60C	22.1KΩ	1/8w ± 1%	Metal Film	Mepco
11	R510	Resistor Fixed	RNR60C	51.1KΩ	1/8w ± 1%	Metal Film	Mepco
12	R511	Resistor Fixed	RC07	5.1KΩ	1/4w ± 5%	Carbon Comp	Allen Bradley
13	R512	Resistor Fixed	RC07	51KΩ	1/4w ± 5%	Carbon Comp	Allen Bradley
14	R513	Resistor Fixed	RNR60C	5.1KΩ	1/8w ± 1%	Metal Film	Mepco
15	R514	Resistor Fixed	RNR60C	5.1KΩ	1.8w ± 1%	Metal Film	Mepco
16	R515	Resistor Fixed	RC07	5.1KΩ	1/4w ± 5%	Carbon Comp	Allen Bradley
17	R516	Resistor Fixed	RC07	51KΩ	1/4w ± 5%	Carbon Comp	Allen Bradley
18	R517	Resistor Fixed	RC07	20KΩ	1/4w ± 5%	Carbon Comp	Allen Bradley
19	R518	Resistor Fixed	RNR60C	10KΩ	1/8w ± 1%	Metal Film	Mepco
20	R519	Resistor Fixed	RNR60C	10KΩ	1/8w ± 1%	Metal Film	Mepco
21	R520	Resistor, Fixed	RC07	240Ω	1/4w ± 5%	Carbon Comp	Allen Bradley

RYAN AERONAUTICAL COMPANY
ELECTRONICS AND SPACE SYSTEMS

COMPONENT PARTS LIST

RUGGEDIZED IMAGING SYSTEM
PHASE I BREADBOARD

BOARD NO. 5

RF, Video and A/PW Converter

ITEM	REF. DESIG.	IDENT.	PART TYPE	VALUE	RATING	MATERIAL	MFG. OR VENDOR
22	R521	Resistor, Fixed	RNR60C	5.11KΩ	1/8w. ± 1%	Metal Film	Mepco
23	R522	Resistor, Fixed	RNR60C	12.1KΩ	1/8w ± 1%	Metal Film	Mepco
24	R523	Resistor, Fixed	RC07	620KΩ	1/4w ± 5%	Carbon Comp	Allen Bradley
25	R524	Resistor, Fixed	RNR60C	10KΩ	1/8w ± 1%	Metal Film	Mepco
26	R525	Resistor, Fixed	RC07	10KΩ	1/4w ± 5%	Carbon Comp	Allen Bradley
27	R526	Resistor, Fixed	RC07	1KΩ	1.4w ± 5%	Carbon Comp	Allen Bradley
28	R527	Resistor, Fixed	RNR60C	10KΩ	1/8w ± 1%	Metal Film	Mepco
29	R528	Resistor, Fixed	RC07	1KΩ	1/4w ± 5%	Carbon Comp	Allen Bradley
30	R529	Resistor, Fixed	RC07	200Ω	1/4w ± 5%	Carbon Comp	Allen Bradley
31	R530	Resistor, Fixed	RNR60C	13.3KΩ	1/8w ± 1%	Metal Film	Mepco
32	R531	Resistor, Fixed	RC07	240Ω	1/4w ± 5%	Carbon Comp	Allen Bradley
33	R532	Resistor, Fixed	RC07	240Ω	1.4w ± 5%	Carbon Comp	Allen Bradley
34	R533	Resistor, Fixed	RNR60C	10KΩ	1.8w ± 1%	Metal Film	Mepco
35	R534	Resistor, Fixed	RNR60C	5.11KΩ	1.8w ± 1%	Metal Film	Mepco
36	R535	Resistor Fixed	RC07	20KΩ	1/4w ± 5%	Carbon Comp	Allen Bradley
37	R536	Resistor, Fixed	RNR60C	7.5KΩ	1.8w ± 1%	Metal Film	Mepco
38	R537	Resistor, Fixed	RC07	100Ω	1/4w ± 5%	Carbon Comp	Allen Bradley
39	R538	Potentiometer	RTR12	5KΩ	1w ± 10%	Wirewound	Bourns
40	R539	Resistor, Fixed	RC07	5KΩ	1/4w ± 5%	Carbon Comp	Allen Bradley
41	R540	Resistor, Fixed	RNR60C	47.5KΩ	1/8w ± 1%	Metal Film	Mepco
42	R541	Resistor, Fixed	RC07	200Ω	1/4w ± 5%	Carbon Comp	Allen Bradley

COMPONENT PARTS LIST

RUGGEDIZED IMAGING SYSTEM
PHASE I BREADBOARD

RYAN AERONAUTICAL COMPANY
ELECTRONICS AND SPACE SYSTEMS

BOARD NO. 5

RF, Video and A/PW Converter

ITEM	REF. DESIG.	IDENT.	PART TYPE	VALUE	RATING	MATERIAL	MFG. OR VENDOR
43	R542	Resistor, Fixed	RC07	10K Ω	1/4w ± 5%	Carbon Comp	Allen Bradley
44	R543	Resistor, Fixed	RC07	10K Ω	1/4w ± 5%	Carbon Comp	Allen Bradley
45	R544	Resistor, Fixed	RC07	200 Ω	1/4w ± 5%	Carbon Comp	Allen Bradley
46	R545	Resistor, Fixed	RNR60C	47.5K Ω	1/8w ± 1%	Metal Film	Mepco
47	R546	Resistor, Fixed	RC07	24 Ω	1/4w ± 5%	Carbon Comp	Allen Bradley
48	R547	Resistor, Fixed	RC07	10K Ω	1/4w ± 5%	Carbon Comp	Allen Bradley
49	R548	Resistor, Fixed	RNR60C	5.11K Ω	1/8w ± 1%	Metal Film	Mepco
50	R549	Resistor, Fixed	RNR60C	28.7K Ω	1/8w ± 1%	Metal Film	Mepco
51	R550	Resistor, Fixed	RNR60C	619K Ω	1/8w ± 1%	Metal Film	Mepco
52	R551	Resistor, Fixed	RC07	15K Ω	1.4w ± 5%	Carbon Comp	Allen Bradley
53	R552	Resistor Fixed	RC07	15K Ω	1/4w ± 5%	Carbon Comp	Allen Bradley
54	R553	Resistor, Fixed	RC07	162K Ω	1/4w ± 5%	Carbon Comp	Allen Bradley
55	R554	Resistor Fixed	RC07	20K Ω	1.4w ± 5%	Carbon Comp	Allen Bradley
56	C500	Capacitor	CKR06	.01 μ fd	±10% 200vdc	Ceramic	Vitramon
57	C501	Capacitor	CKR06	.1 μ fd	±10% 100vdc	Ceramic	Vitramon
58	C502	Capacitor	CKR06	.01 μ fd	±10% 200vdc	Ceramic	Vitramon
59	C503	Capacitor	05TA103GN	.01 μ fd	±2% 50vdc	Teflon	Component Research
60	C504	Capacitor	CYR	68 pfd	±10% 500vdc	Glass	Corning
61	C505	Capacitor	CYR	68 pfd	±10% 500vdc	Glass	Corning
62	C506	Capacitor	CKR06	.01 μ fd	±10% 200vdc	Ceramic	Vitramon

COMPONENT PARTS LIST

RUGGEDIZED IMAGING SYSTEM
PHASE I BREADBOARD

RYAN AERONAUTICAL COMPANY
ELECTRONICS AND SPACE SYSTEMS

BOARD NO. 5
RF, Video and A/PW Converter

ITEM	REF. DESIG.	IDENT.	PART TYPE	VALUE	RATING	MATERIAL	MFG. OR VENDOR
63	C507	Capacitor	CYFR	47 pfd	±10% 500vdc	Glass	Corning
64	C508	Capacitor	CYFR	47 pfd	±10% 500vdc	Glass	Corning
65	C509	Capacitor	CKR06	.001 μ fd	±10% 200vdc	Ceramic	Vitramon
66	C510	Capacitor	CKR06	.0012 μ fd	±10% 200vdc	Ceramic	Vitramon
67	C511	Capacitor	CYFR	(3900 pfd / 240 pfd)	± 2% 300vdc	Glass	Corning
68	C512	Capacitor	CYFR	820 pfd	±10% 500vdc	Glass	Corning
69	C513	Capacitor	CSR13	15 μ fd	±10% 20vdc	Solid Tantalum	Sprague
70	C514	Capacitor	PV224	.22 μ fd	±2% 30vdc	Polycarbonate	Component Research
71	C515	Capacitor	CSR13	47 μ fd	±10% 20vdc	Solid Tantalum	Sprague
72	C516	Capacitor	CSR13	10 μ fd	±10% 10vdc	Solid Tantalum	Sprague
73	C517	Capacitor	CKR06	.1 μ fd	±10% 100vdc	Ceramic	Vitramon
74	C518	Capacitor	CKR06	.1 μ fd	±10% 100vdc	Ceramic	Vitramon
75	C519	Capacitor	CKR06	.1 μ fd	±10% 100vdc	Ceramic	Vitramon
76	C520	Capacitor	05TJ502	.005 μ fd	±2% 50vdc	Teflon	Component Research
77	Q500	Transistor	2N2432				
78	Q501	Transistor	2N2432				
79	Q502	Transistor Fet	2N3963				
80	Q503	Transistor	2N2432				
81	Q504	Transistor Fet	2N3969				
82	Q505	Transistor	2N2432				
83	Q506	Transistor	2N2907A				

RYAN AERONAUTICAL COMPANY
ELECTRONICS AND SPACE SYSTEMS

COMPONENT PARTS LIST

RUGGEDIZED IMAGING SYSTEM
PHASE I BREADBOARD

BOARD NO. 5
RF, Video and A/PW Converter

ITEM	REF. DESIG.	IDENT.	PART TYPE	VALUE	RATING	MATERIAL	MFG. OR VENDOR
84	Q507	Transistor	2N930				
85	Q508	Transistor	2N930				
86	Q509	Transistor Dual Fet	2N3954				
87	Q510	Transistor Dual	2N4878				
88	Q511	Transistor Dual	2N4023				
89	CR500	Diode	1N916				
90	CR501	Diode	1N916				
91	CR502	Diode	1N916				
92	CR503	Diode	1N916				
93	CR504	Diode	1N916				
94	CR505	Diode	1N916				
95	CR506	Diode	1N916				
96	CR507	Diode	1N916				
97	CR508	Diode	1N916				
98	CR509	Diode, Reference	1N827A				
99	CR510	Diode	FD306				
100	IC500	Integrated Ckt	CA3010	To-5			RCA
101	IC501	Integrated Ckt	CA3010	To-5			RCA
102	IC502	Integrated Ckt	FN484	To-18			Siliconix
103	IC503	Integrated Ckt	FN484	To-18			Siliconix
104	IC504	Integrated Ckt	μA710	To-5			Fairchild

RYAN AERONAUTICAL COMPANY
ELECTRONICS AND SPACE SYSTEMS

COMPONENT PARTS LIST

RUGGEDIZED IMAGING SYSTEM
PHASE I BREADBOARD

BOARD NO. 5
RF, Video and A/PW Converter

ITEM	REF. DESIG.	IDENT.	PART TYPE	VALUE	RATING	MATERIAL	MFG. OR VENDOR
105	IC505	Integrated Ckt	D111F	Flat Pack			
106	L500	Inductor	93282	82 μ hy	± 5%	Min. Toroid	Vanguard

COMPONENT PARTS LIST

RUGGEDIZED IMAGING SYSTEM
PHASE I BREADBOARD

RYAN AERONAUTICAL COMPANY
ELECTRONICS AND SPACE SYSTEMS

BOARD NO. 6

LOW VOLTAGE POWER SUPPLY

ITEM	REF. DESIG.	IDENT.	PART TYPE	VALUE	RATING	MATERIAL	MFG. OR VENDOR
1.	R600	Resistor, Fixed	RC07	100	1/4w ±5%	Carbon Comp.	Allen Bradley
2.	R601	Resistor, Fixed	RWR70	1	1w ±1%	Wire Wound	Dale
3.	R602	Resistor, Fixed	RWR70	7.5	1w ±1%	Wire Wound	Dale
4.	R603	Resistor, Fixed	RWR70	5.1	1w ±1%	Wire Wound	Dale
5.	R604	Resistor, Fixed	RWR70	2.7	1w ±1%	Wire Wound	Dale
6.	R605	Resistor, Fixed	RWR70	2.7	1w ±1%	Wire Wound	Dale
7.	R606	Resistor, Fixed	RWR70	5.1	1w ±1%	Wire Wound	Dale
8.	R607	Resistor, Fixed	RWR70	33	1w ±1%	Wire Wound	Dale
9.	R608	Potentiometer	RTR12	1K	1w ±10%	Wirewound	Bourns
10.	R609	Resistor, Fixed	RC07	4.7K	1/4w ±5%	Carbon Comp.	Allen Bradley
11.	R610	Potentiometer	RTR12	500	1w ±10%	Wirewound	Bourns
12.	R611	Potentiometer	RTR12	500	1w ±10%	Wirewound	Bourns
13.	R612	Potentiometer	RTR12	1K	1w ±10%	Wirewound	Bourns
14.	R613	Resistor, Fixed	RC07	33	1/4w ±5%	Carbon Comp.	Allen Bradley
15.	C600	Capacitor	1PL205J	2.0 μfd	±5% 100VDC	Polycarbonate	Component Research
16.	C601	Capacitor	CLR65	270 μfd	±10% 15VDC	Solid Tantalum	Sprague
17.	C602	Capacitor	CLR65	390 μfd	±10% 10VDC	Solid Tantalum	Sprague
18.	C603	Capacitor	CLR65	390 μfd	±10% 10VDC	Solid Tantalum	Sprague
19.	C604	Capacitor	CLR65	390 μfd	±10% 10VDC	Solid Tantalum	Sprague
20.	C605	Capacitor	CLR65	390 μfd	±10% 10VDC	Solid Tantalum	Sprague
21.	C606	Capacitor	CLR65	150 μfd	±10% 30VDC	Solid Tantalum	Sprague
			CLR65				

COMPONENT PARTS LIST

RUGGEDIZED IMAGING SYSTEM
PHASE I BREADBOARD

RYAN AERONAUTICAL COMPANY
ELECTRONICS AND SPACE SYSTEMS

BOARD NO. 6

ITEM	REF. DESIG.	IDENT.	PART TYPE	VALUE	RATING	MATERIAL	MFG. OR VENDOR
22.	C607	Capacitor	CLR65	180 μ fd	±10% 25VDC	Solid Tantalum	Sprague
23.	C608	Capacitor	CLR65	180 μ fd	±10% 25VDC	Solid Tantalum	Sprague
24.	C609	Capacitor	CLR65	150 μ fd	±10% 30VDC	Solid Tantalum	Sprague
25.	C610	Capacitor	CSR13	22 μ fd	±10% 35VDC	Solid Tantalum	Sprague
26.	C611	Capacitor	CSR13	22 μ fd	±10% 35VDC	Solid Tantalum	Sprague
27.	C612	Capacitor	CSR13	68 μ fd	±10% 15VDC	Solid Tantalum	Sprague
28.	C613	Capacitor	CSR13	68 μ fd	±10% 15VDC	Solid Tantalum	Sprague
29.	Q600	Transistor	2N2905A				
30.	Q601	Transistor	2N2219A				Sem-Tech
31.	CR600	Diode	1N4942				
32.	CR601	Diode	1N4942				
33.	CR602	Diode	1N4942				
34.	CR603	Diode	1N4942				
35.	CR604	Diode	1N4942				
36.	CR605	Diode	1N4942				
37.	CR606	Diode	1N4942				
38.	CR607	Diode	1N4942				
39.	CR608	Diode	1N4942				
40.	CR609	Diode	1N4942				
41.	CR610	Diode	1N4942				
42.	CR611	Diode	1N4942				

COMPONENT PARTS LIST

RUGGEDIZED IMAGING SYSTEM
PHASE I BREADBOARD

RYAN AERONAUTICAL COMPANY
ELECTRONICS AND SPACE SYSTEMS

BOARD NO. 6

ITEM	REF. DESIG.	IDENT.	PART TYPE	VALUE	RATING	MATERIAL	MFG. OR VENDOR
43.	CR612	Diode	1N4942				
44.	CR613	Diode	1N4942				
45.	CR614	Diode	1N4942				
46.	CR615	Diode	1N4942				
47.	IC600	Integrated Ckt.	PC 503H	Flat Pak			Genl Inst
48.	IC601	Integrated Ckt.	PC 523H	Flat Pak			Genl Inst
49.	IC602	Integrated Ckt.	PC 521H	Flat Pak			Genl Inst
50.	IC603	Integrated Ckt.	PC 501H	Flat Pak			Genl Inst
51.	T600	Transformer	EWT 149 (JPL)			Toroid	JPL

COMPONENT PARTS LIST

RUGGEDIZED IMAGING SYSTEM
PHASE I BREADBOARD

RYAN AERONAUTICAL COMPANY
ELECTRONICS AND SPACE SYSTEMS

BOARD NO. 7

HIGH VOLTAGE POWER SUPPLY

ITEM	REF. DESIG.	IDENT.	PART TYPE	VALUE	RATING	MATERIAL	MFG. OR VENDOR
1.	R700	Resistor, Fixed	RC07	10K	1/4w ±5%	Carbon Comp.	Allen Bradley
2.	R701	Resistor, Fixed	RC07	390K	1/4w ±5%	Carbon Comp.	Allen Bradley
3.	R702	Potentiometer	RJ12	1MEG	1/4w ±10%	Carbon	Bourns
4.	R703	Potentiometer	RJ12	1MEG	1/4w ±10%	Carbon	Bourns
5.	R704	Resistor, Fixed	RC07	1.5MEG	1/4w ±5%	Carbon Comp.	Allen Bradley
6.	R705	Potentiometer	RJ12	100K	1/4w ±10%	Carbon	Bourns
7.	R706	Resistor, Fixed	RC07	120K	1/4w ±5%	Carbon Comp.	Allen Bradley
8.	R707	Potentiometer	RJ12	50K	1/4w ±10%	Carbon	Bourns
9.	R708	Potentiometer	RTR12	20K	1w ±10%	Wirewound	Bourns
10.	R709	Resistor, Fixed	RC07	680	1/4w ±5%	Carbon Comp.	Allen Bradley
11.	R710	Resistor, Fixed	RC07	1K	1/4w ±5%	Carbon Comp.	Allen Bradley
12.	R711	Potentiometer	RJ12	1MEG	1/4w ±10%	Carbon	Bourns
13.	R712	Resistor, Fixed	RC07	240	1/4w ±5%	Carbon Comp.	Allen Bradley
14.	C700	Capacitor	118P	.01 μ fd	±10% 1KVDC	Paper-Mylar	Sprague
15.	C701	Capacitor	118P	.01 μ fd	±10% 1KVDC	Paper-Mylar	Sprague
16.	C702	Capacitor	118P	.01 μ fd	±10% 600VDC	Paper-Mylar	Sprague
17.	C703	Capacitor	118P	.01 μ fd	±10% 600VDC	Paper-Mylar	Sprague
18.	C704	Capacitor	118P	.02 μ fd	±10% 600VDC	Paper-Mylar	Sprague
19.	C705	Capacitor	118P	.02 μ fd	±10% 600VDC	Paper-Mylar	Sprague
20.	C706	Capacitor	118P	.02 μ fd	±10% 600VDC	Paper-Mylar	Sprague
21.	C707	Capacitor	118P	.02 μ fd	±10% 600VDC	Paper-Mylar	Sprague

COMPONENT PARTS LIST

RUGGEDIZED IMAGING SYSTEM
PHASE I BREADBOARD

RYAN AERONAUTICAL COMPANY
ELECTRONICS AND SPACE SYSTEMS

BOARD NO. 7

ITEM	REF. DESIG.	IDENT.	PART TYPE	VALUE	RATING	MATERIAL	MFG. OR VENDOR
22.	C708	Capacitor	D E	L	E T	E	
23.	C709	Capacitor	CKR06	1 μfd	±10% 200VDC	Ceramic	Vitramon
24.	C710	Capacitor	CKR06	1 μfd	±10% 200VDC	Ceramic	Vitramon
25.	C711	Capacitor	CKR06	.047 μfd	±10% 100VDC	Ceramic	Vitramon
26.	C712	Capacitor	CKR06	.01 μfd	±10% 200VDC	Ceramic	Vitramon
27.	CR700	Diode	IN4947				Sem-Tech
28.	CR701	Diode	IN4947				Sem-Tech
29.	CR702	Diode	IN4947				Sem-Tech
30.	CR703	Diode	IN4947				Sem-Tech
31.	CR704	Diode	IN4945				Sem-Tech
32.	CR705	Diode	IN4945				Sem-Tech
33.	CR706	Diode	IN4945				Sem-Tech
34.	CR707	Diode	IN4945				Sem-Tech
35.	CR708	Diode	IN4942				Sem-Tech
36.	CR709	Diode	IN4942				Sem-Tech
37.	CR710	Diode	IN4942				Sem-Tech
38.	CR711	Diode	IN4942				Sem-Tech
39.	CR712	Diode	IN916				
40.	Q700	Transistor	40385				RCA
41.	T700	Transformer	EWT 150 B (JPL)			Toroid	JPL